Can Meaning Associated with Perceptual Grouping Modulate Attention?

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SUPERVISORY AND EXAMINING COMMITTEE

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Abstract

In an environment rich with information, performance on a task depends on the ability to select only the relevant pieces of information for achieving a current goal. Cognitive psychologists propose that selective attention helps to segregate the relevant information from the irrelevant information. A combination of bottom-up and top-down factors jointly influences the settings of the attentional filter (Spalek, Falcon & Di Lollo, 2006) such that only task-relevant information is selected for further processing. However, biologically- and socially-important stimuli like affective faces are proposed to influence allocation of attention (Vuilleumier & Schwartz, 2001). Task-irrelevant emotional faces are proposed to capture attention in a way that is detrimental to performance on a primary task (Eastwood, Smilek & Merikle, 2003). The present study was carried out to examine whether task-irrelevant affective faces can capture attention even when attention is maintained in a focused mode. Subjects searched for a unique red target letter (T2) in a stream of black distractor letters presented at the rate of 1item per 84 ms in an RSVP sequence. Two straight lines and a curve were also presented in the periphery and in the same frame as a distractor letter (T1). The perceptual groups formed by the specific arrangements of the peripheral elements (face/ non-face), the time interval between T1 and T2 (lag), and the colour (black irrelevant / red relevant) of the peripheral elements were manipulated. The extent to which the peripheral elements captured attention was measured as differences in the accuracy with which T2 was identified in these different conditions. The results from six experiments indicate that T2 identification was impaired by lag and relevance but not by the presence of a face. Contrary to claims made in the literature the results of the present study indicated that distractions from socially-important stimuli like affective Gestalt faces can be averted when the spread of spatial attention is controlled and when these stimuli do not match the top-down settings adopted for the current task. The observations made in the present study also suggest possible differences between the mechanisms involved when a target is searched in space than when a target is searched in time.

Keywords: face, perceptual groupings, attentional capture

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Dedication

This thesis is dedicated to my parents who inspired me, supported me and taught me to focus on the most important aspects of life.

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1. Introduction

According to the mythological epic tale of Mahabarata composed some 2500 years ago in Ancient India, Prince Arjun from the kingdom of Hastinapur was believed to have exceptional ability to concentrate and focus. Arjun's extraordinary skills were identified early on when the royal guru Dronacharaya conducted a test to monitor the progress of his royal students. The task was to shoot the eye of a bird that was placed on a branch of a tree. Dronacharya asked each of his disciples, one at a time, to step in front of the target and take aim. When the students were ready, he asked each of them what they saw. To his question, each of the princes replied that they saw a variety of objects present around them, such as their esteemed guru, their brothers, the branch of the tree, leaves, and the bird's eye. Disappointed, Dronacharya asked each of them to step aside informing them that they were not ready for the task. Finally, when Dronacharya asked Arjun what he saw, Arjun replied that all he saw was the eye. Pleased with Arjun's reply Dronacharya asked him to shoot the target and needless to say Arjun hit the target very accurately. Later Dronacharya explained to all his disciples that to shoot a target accurately one needs to withdraw attention from all other non-targets irrespective of their general importance or significance and focus solely on the target.

A detailed analysis of Dronacharya's lesson reveals two important aspects of attention and target identification. First, Dronachrya points out that accurate aim or target detection is possible when attentional resources are withdrawn from all other non-targets in the environment and focused narrowly over the known target location. Interestingly, evidence for this claim can be found in the modern attention literature examining visual search for a target in a task employing the cueing paradigm (Benso, Turatto, Gastone and

Umilta, 1998; Egly, Driver, & Rafal, 1994; Eriksen & St. James, 1986; Posner, 1980; Posner, Snyder & Davidson, 1980). All these studies report a significantly enhanced ability to detect or identify a target when attention is directed to the target location. Second, Dronacharya also implied that attentional resources are limited and allocation of finite attentional resources to irrelevant objects in a visual field leaves fewer resources for processing the target, thereby impairing the primary task. Evidence of this claim can again be found in the attention literature showing that performance on a primary task is impaired when attentional resources are allocated to task-irrelevant stimuli of social and biological importance like emotional faces (Eastwood, Smilek & Merikle, 2003), familiar cartoon pictures (Forster & Lavie, 2008) and words with sexual content (Arnell, Killman, & Fijavz, 2007). Dronacharya's lessons are of special relevance to modern attention research because they make an interesting proposition. That is, under certain conditions it is possible to withdraw attentional resources from all non-target items in the visual field irrespective of their general importance and significance and direct them towards a target. Interestingly, there is also evidence suggesting that interference from affective faces can be averted when the primary task is attentionally-demanding (Pessoa, McKenna, Gutierrez, & Ungerleider, 2002).

The story emphasizes the role of individual characteristics that allow withdrawal of attentional resources from socially- and biologically-important non-targets. In the present study I investigated situational factors that might facilitate withdrawal of attentional resources from peripherally-located socially-important distractors by creating a situation in which the focus of attention would be maintained narrowly over a target location. By manipulating both the pre-existing and the experimentally-defined meaning

Figure 1 Four dots perceived as a box

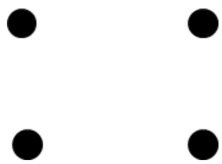


Figure 1a: Gestalt principles of perceptual grouping

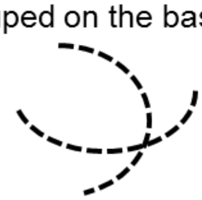
Items grouped on the basis of similarity

X X X X X X X
N N N N N N N   Perceived as rows
B B B B B B B

Items grouped on the basis of proximity

X	X	X	Perceived as column
X	X	X	
X	X	X	
X	X	X	

Items grouped on the basis of continuity



associated with a perceptual group (or a group of independent objects sharing a common feature; please refer to Figure 1and 1a), I investigated whether it might be possible to avoid the distraction caused by biologically and socially-important stimuli. Further, I was interested in understanding the way in which target identification and representation are impacted by allocating attention to task-irrelevant perceptual groups. In the next sections I will discuss different theories of attention, factors that modulate attention, the purpose of the study, the design of the proposed experiments, the results, and the main findings of the study.

The various functions of attention have been studied in detail in the context of individuals' ability to search for targets in a visual field. In the following section I will discuss theories that examine the role of spatial attention in target identification.

1.1 Spotlight Model of Attention

Posner (1980) showed that the time taken to detect a target (response time, RT) was reduced when a cue indicated the location at which a target was likely to appear. Two processes were described to explain the way that knowledge of target location enhanced its detection. When a location was cued, attention was shifted in the direction of the cue, a process referred to as orienting. Shifting attention to the cued location increased the likelihood that any information presented at the cued location would be encoded and thus could be reported with an arbitrary response specified by the experimenter. This process was referred to as detection. Orienting was proposed to take place without requiring overt eye movements. The benefit of the knowledge of target location could not be accounted for by any intrinsic feature of the target itself such as high stimulus intensity or greater perceptual contrast when compared to the background.

Posner et al. (1980) observed that attention could only be allocated to the cued location and could not be maintained at multiple locations simultaneously. In Experiment 5 of their paper, Posner et al. observed faster RTs when a target appeared in a position adjacent to the cued location compared to a position non-adjacent to the cued location. Additionally, RTs were faster for a target located at the centre of the cued location than when it was located in the periphery of the cued location. This suggests that finite attentional resources can be allocated to one small area in the visual field at a time, thereby bringing the specific area and all objects present in that location under the attentional spotlight. As a result, a target present in the attentional spotlight is detected with greater efficiency. Further, the attentional spotlight can be directed to specific locations in the visual field by a cue.

The area over which the attention spotlight is spread can be adjusted according to the demands of the task at hand (Jefferies & Di Lollo, 2009; Laberge, 1983) and by presenting a cue of varying size (Benso et al., 1998). Information is processed with differential efficiency across the area encompassed by the spotlight, with greater efficiency observed at the centre than at the periphery (Cave & Bichot, 1999). The time taken to detect a target is faster with smaller cues (Benso et al., 1998) suggesting that costs are associated with spreading the focus of attention over a larger area. The consequence of spreading attention over a larger area has been examined in detail in the zoom lens model of attention.

1.2 The Zoom Lens Model of Attention

The zoom lens model proposed by Eriksen and St. James (1986) can be viewed as an extension of the spotlight model with some added functionalities. This model, like the spotlight model of attention, proposes that information presented within the area encompassed by attention will be processed with greater efficiency. However, this model also proposes that the area over which attention is spread can be adjusted by a precue in the same way as the resolution of a zoom lens can be altered. Eriksen and St. James showed that the presence of a cue before a target was displayed was beneficial to target detection. In their study subjects searched for a single target letter from an eight letter circular display. On some trials a critical distractor appeared in a location near the target and on other trials the distractor appeared further away. The critical distractor was an item that served as a target on other trials; therefore, it was associated with a competing response. If this distractor cannot be filtered out the response associated with it would be activated thus creating interference and slowing responses to the target. One to four letters were pre-cued by underlining the letters. Eriksen and St. James found that interference from these critical distractors presented three positions away from the cued location was reduced when the time between the cue and the stimulus display was increased. This suggests that with sufficient time the attentional zoom lens can be readjusted to encompass the cued location only, thereby reducing distractions from surrounding non-cued locations. It is important to note that in these experiments the stimulus display was arranged on an imaginary circle with a radius of 1.5° visual angle and was centred well within the fovea. Therefore eye movements or the increased difficulty associated with seeing items presented outside the fovea cannot account for the results. Finally, although subjects were given substantial time to focus on a cued location, interference from noise presented within 1° of the target location could not be eliminated. The authors proposed that in the absence of a cue, attention was spread over the entire stimulus display. So, target detection was vulnerable to interference from noise located further away from the target. When a particular location was cued, the focus of attention zoomed in over that location. A certain amount of time was required to achieve this adjustment. When the time between the cue and the stimulus display was short (50 ms) the withdrawal of attentional resources from the irrelevant positions was still underway, and as a result, noise presented three positions away from the cued location interfered with target detection. However, with a lead time of 100 ms the zoom lens was adjusted optimally to encompass the cued location only, so interference from noise located three positions away was reduced. An increase in RT was also observed with an increase in the number of locations cued. This suggests that the density of attentional resources decreases with an increase in the area over which attention was spread, leading to decreased resolution of the focus of attention.

In summary, the zoom lens model of attention describes how attentional resources are selectively allocated to particular locations in a visual field, increasing the efficiency of target detection in those areas.

1.3 Object-based Attention

Describing attention in terms of the area it encompasses, as the research summarized in the preceding sections does, underscores that attention can be directed to a particular location in space. However, Duncan (1984) has proposed that attention can also be allocated to specific objects in a visual field irrespective of their location, highlighting the distinction between object-based attention and spatial attention. In contrast to distinguishing between two forms of attention in target identification, others (e.g., Chen, 1998; Egly et al. 1994; Richard, Lee & Vecera, 2008) have suggested that object-based attention operates in conjunction with space; that is; the space occupied by an object selected by attention is selected with the object. Further, by cueing a part of an object, attention is observed to spread over the entire area encompassed by the object. The location encompassed by a cued object receives attentional resources and is thereby prioritised over the locations encompassed by non-cued objects during information processing or visual search (Egly et al., 1994).

Evidence for the object-based nature of spatial attention is reported by Egly et al. (1994). In this study, the stimulus display consisted of two rectangles presented on either side of a fixation cross. On each trial, one end of one rectangle was cued exogenously. The target appeared in the cued location 75% of the time (valid cue) and in the non-cued location 25% of the time (invalid cue). On the invalidly cued trials the target could appear within the non-cued end of the cued rectangle or within the non-cued end of the non-cued rectangle. The distance between fixation and the target location was held constant irrespective of whether the target was presented in the cued or non-cued rectangle on invalidly-cued trials. Target detection was faster when targets appeared in the cued location than in the non-cued location, confirming that target detection is facilitated when presented in the area where attention is already allocated. Interestingly, Egly et al. also found that on the invalidly-cued trials, detection was faster when the target was presented within the cued rectangle than within the non-cued rectangle even though the distance between the cue and the target locations was the same. Summarizing the results, the authors proposed that attention spreads over the space encompassed by the cued object as a whole thereby facilitating detection of targets presented anywhere within that object. This was referred to as the same-object benefit.

Chen and Cave (2008) used an endogenous cueing procedure to examine object-based attention. They reported evidence of object-based attention even when the target location was known with certainty because the target was preceded by an endogenous cue indicating the target location with 100% validity. This indicates that objects may be used as reference frames for the allocation and spread of attention in the visual field. Further, this reference frame was most likely used to determine the relative location of the target in a visual field. The target was brought under the focus of attention when its location was perceived to fall within the contours of the cued object.

Interestingly, a group of objects without discrete boundaries can also be perceived as a single unified object. Objects sharing a common feature are often grouped together to form a perceptual group. Perceptual grouping leads to the formation of a new object that is not defined by discrete boundaries (Marrara & Moore, 2003). In Figure 1 the four circles are grouped together and perceived as a square although the circles are not joined by a discrete boundary. To avoid confusion between independent objects and objects that form part of a perceptual group, objects forming a perceptual group will henceforth be referred to as *elements*. According to the Gestalt principles of perceptual grouping, various items in a visual field can be grouped on the basis of bottom-up factors such as similarity, spatial proximity, and continuation. The Gestalt principles are considered to be universal, with grouping occurring irrespective of prior exposure to such groupings. However, the groupings can be influenced by top-down factors such as instructions (Chen, 1998), knowledge (Girgus, Rock, & Egatz, 1977; Peterson & Gibson, 1994), training (Vickery & Jiang, 2009) and familiarity (Humphreys & Riddoch, 2007; Kumada & Humphreys, 2001).

1.4 How Does Perceptual Grouping Modulate Attention?

Perceptual grouping can modulate the allocation of attention in several ways**.** First, formation of perceptual groups allows the displayed stimulus to be organised in a particular way. These organizations then form a frame of reference, guiding allocation of attention to specific locations (Chen, 1998; Marino & Scholl, 2005; Marrara & Moore, 2003; Vecera, 1994) and objects in the visual field (Dodd & Pratt, 2005; Linnell & Humphreys, 2007), thereby enhancing target identification. Alternatively, target identification can also be impaired by the formation of perceptual groups, especially when attention is captured by the identity of the perceptual group as a whole and the identities of individual elements are amalgamated within the identity of the perceptual groups as a whole (Eastwood et al., 2003; Humphreys & Riddoch, 2007). Studies that examine the way in which meanings or identities associated with perceptual groups modulate the allocation of attention in a visual field are especially relevant in the present context.

1.5 Reducing Competition Between Individual Objects

In a visual search task the target location is unknown so attentional resources have to be deployed to as many locations or objects as possible to maximize target detection. Because attentional resources are finite, sampling multiple locations or objects concurrently is a challenge (Posner et al., 1980). Some of this competition between individual objects was observed to be reduced when individual objects formed a perceptual group (Kumada & Humphreys, 2001; Linnell & Humphreys, 2007) because perceptual groups are perceived and attended as a whole. Linnell and Humphreys (2007) observed that target identification was enhanced when a peripherally located target grouped with a centrally located distractor set on the basis of a shared feature like colour. Linnell and Humphreys proposed that the perceptual group formed between the target and the distractor set on the basis of bottom–up similarity "pulled" the peripherally located target towards the centre and brought it under the focus of spatial attention, enhancing performance. Studies examining cognitive functioning in individuals with spatial extinction[1] also show that individual elements within the perceptual group receive the same amount of attentional resources as they do when they do not form a perceptual group. Individuals suffering from spatial extinction are able to report a single item when presented on either the ipsilesional or contralesional side of space[2] (Humphreys & Riddoch, 2007). However, the ability to report an item on the contralesional side is impaired by the simultaneous presentation of a second stimulus on the ipsilesional side (Humphreys & Riddoch, 2007). Kumada and Humphreys (2001) proposed that this attentional deficit arises due to an abnormal tendency to allocate attentional resources to the ipsilesional side at the cost of the contralesional side. However, Kumada and Humphreys (2001) found that it was possible to overcome extinction and report both stimuli when the two letters formed a perceptual unit on the basis of bottom–up features (same colour) or formed a meaningful unit (a word). They also found that perceptual grouping was favoured by co-occurrence (letters grouped meaningfully) in the absence of bottom-up salience. Although the letters appeared in two different colours, they were grouped when they formed a meaningful word. Humphreys and Riddoch (2007) proposed that with repeated exposures to certain configurations of elements the visual system

[1] The spatial bias that occurs in visual selection of items presented on the ipsilateral side when items are presented on both ipsilateral and contralateral side (Kumada & Humphreys, 2001)
[2] Ipsilateral side is the side of the brain on which the lesion or damage is located, contralesional side is the side opposite to which the damage is caused.

begins to treat these groups as units rather than just clusters consisting of several independent objects. The identity of the unit that emerges from the combination of elements is richer and more complex than the identities of the elements themselves. For example, the identity of the word '**मा**' (which means mother in Hindi, an Indian language) is much more than just the sounds of the two letters '**म**' (similar to 'm' sound in English) and 'ा' ('aa' sound in English) put together. For an individual not aware of the Hindi language '**मा**' might still be perceived as a perceptual group formed by the spatial proximity of the two characters. However, for a person with knowledge of Hindi language this is perceived as a unit which bears a much richer identity compared to the identity that emerges when the unit is perceived as a cluster of two characters. Although formation of units might enhance identification of individual elements in some situations, there is evidence suggesting that the identities of individual elements are difficult to distinguish from that of the perceptual group as a whole as was observed by Humphreys and Riddoch (2007).

1.6 Identities of the Perceptual Group and Allocation of Attention

Humphreys and Riddoch (2007) proposed that with repeated exposures or practise the visual system develops certain internal representations of familiar perceptual groups or units. These internal representations are then used as references to make decisions about a stimulus at hand. Identities of elements in a perceptual group are influenced by the way in which individual elements are connected to each other within the perceptual group. Further, this relationship might override knowledge and awareness of identities of individual elements involved in the perceptual group. This becomes evident when one looks at the Müller-Lyer illusion in which one is required to judge the length of two lines

(Humphreys & Riddoch, 2007). Even with prior knowledge about the illusions, the lines in the illusion appear to be of different lengths depending on whether the ends of the lines are presented as arrow heads or as fins. This suggests that the visual system references the relationship between different elements in the visual field while making judgements about individual elements. Although reference to learned perceptual groups and their associated meanings might be detrimental to performance on a task, experiments have consistently reported such tendencies (Eastwood, Frischen, Reynolds, Gerritsen, Dubin, & Smilek, 2008; Eastwood et al., 2003).

1.7 Do Faces Affect the Allocation of Spatial Attention?

There is substantial evidence in the literature suggesting that an object or perceptual group with a meaning that is of biological or social importance influences the way individuals make responses to arbitrary stimuli in an experimental setting (Eastwood et al., 2008; Eastwood et al., 2003; Lavie, Ro, & Russell, 2003; Ro, Lavie, & Russell, 2001; Suzuki & Cavanagh, 1995). Of special relevance in the present context is Eastwood et al.'s (2003) observation that allocation of spatial attention in a visual field is influenced by the meanings associated with perceptual groups formed by organizing the stimulus display in a certain way. The stimulus display in this study consisted of arcs facing upwards or downwards. These arcs could be grouped in threes and perceived as Gestalt faces representing negative or positive emotions. Subjects in this study were required to count the number of arcs facing upwards or downwards. Performance was especially impaired on the trials on which the perceptual group reflected negative emotions although the task did not require organization of the visual field into perceptual groups and the identities of the perceptual groups were task-irrelevant. Additionally, focusing attention narrowly over an object or particular segments of the visual field (local level processing; Raushcenber & Yantis, 2001) was most advantageous for performance in this case. However, the presence of socially important stimuli like the affective faces in this experiment was proposed to capture spatial attention in a way that induced global level processing, in turn impairing performance on the primary task which required local level processing (Eastwood et al., 2003).

Vuilleumier and Schwartz (2001) also observed that allocation of spatial attention is modulated by the presence of socially and biologically important stimuli like faces. Examining cognitive functioning in individuals with unilateral spatial neglect[3] and visual extinction, Vuilleumier and Schwartz (2001) observed that face stimuli and faces with emotional expressions presented on the contralesional side were less likely to be extinguished than non-face shapes and neutral faces. Further, Lavie et al. (2003) observed that face stimuli influenced performance on a primary task even under high perceptual load. In this study subjects determined whether a name displayed at fixation belonged to a statesman or a pop star. The name was presented along with other non-targets consisting of strings of letters and the magnitude of perceptual load was varied by manipulating the number of distractors accompanying the name (set size). Additionally, the face of a famous person also appeared in the periphery. Lavie et al. hypothesised that the ability to categorise the name would be influenced by whether or not the face-name pair was congruent (i.e., the face and name belonged to the same category – statesman or pop star), with better performance expected on congruent trials than on incongruent trials. However, this effect was expected to be attenuated under high perceptual load due to

[3] Loss of awareness for stimuli presented on the left side when there is damage on the right parietal cortex but no physiological damage to the visual pathways, (Vuilleumier & Schwartz, 2001)

unavailability of resources to process distractors. Superior performance was observed on trials on which the face-name pair was congruent but contrary to the hypothesis, the task-irrelevant faces were processed even under high load. Lavie et al. proposed that due to the biological and social importance of faces, these stimuli cannot be ignored and can be processed with limited or no attentional resources. Further evidence of this claim was found by Forster and Lavie (2008) who had subjects make speeded responses to indicate the presence or absence of a target letter (‘X’ or ‘N’). The target letter was presented with distractor letters arranged in a circle. Additionally, any one of six cartoon characters that was completely distinct from the target letter (and therefore absolutely task-irrelevant) was presented at the periphery away from the location of the stimulus. Subjects were explicitly instructed to ignore these stimuli and focus on the primary task. Interestingly, attention was captured by task-irrelevant cartoon characters and performance on the primary task was impaired irrespective of whether or not the target was a singleton. This shows that certain objects can be processed even when the attentional filter is not set to be especially lenient. Greater attentional capture was also observed when the task-irrelevant images were meaningful (cartoon characters) than when they were meaningless (cartoon shapes like thunder).

Consistent with the prioritised face processing view, accurate perception of facial expressions, especially threatening emotions, is also proposed to be important for survival (Hansen & Hansen, 1988). Faces expressing negative emotions such as anger are detected faster than happy faces (Fox, Lester, Russo, Bowless, Pichler & Dutton, 2000) or neutral faces (Schübo, Gendolla, Meinecke & Abele, 2006). Lipp, Price, and Tellegen (2009) found that identifying the emotional valence of a face was not impaired when holistic processing of faces was disrupted by inverting the face stimuli. Performance using schematic faces was comparable to photographed face stimuli (Lipp et al., 2009), showing that emotional information can be extracted from a minimalist depiction of a face (also see Watson, Blagrove, Evan & Moore, 2012). Neurological evidence shows increased amygdala activity (considered to reflect emotional processing) in the presence of angry faces (Ohman, 2002) or fearful faces even when these faces were not within the focus of attention, suggesting that these stimuli can be processed automatically or without focal attention (Anderson, Christoff, Panitz, Rosa, & Gabriele, 2003; Vuilleumier, Armony, Driver, & Dolan, 2001).

In summary, accurate perception of faces and emotions is important for survival, so it is reasonable to expect that the most relevant information in faces would be extracted automatically and preattentively (Ohman, 2002; Vuilleumier et al., 2001). The presence of such stimuli can interfere with the primary task in several ways. First, such stimuli can affect allocation of attention to objects or locations in the visual field and in particular, meaningful stimuli capture spatial attention more effectively than meaningless stimuli (Forster & Lavie, 2008). Second, the presence of faces and emotional information can lead to the structuring of the visual field in a particular way and further assessments of the same stimulus pattern can be accomplished only with reference to the meaning that was initially derived (Eastwood et al., 2003). Third, emotionally salient stimuli can capture attention such that attention is unavailable for processing of subsequent targets (Arnell et al. 2007; Most, Chun, Widder & Zald, 2005). Finally, the presence of emotional faces can induce a suboptimal level (global over local) of processing leading to slow target identification (Eastwood et al., 2003).

1.8 Summary of Findings from the Spatial Attention Literature

Summarising the findings of spatial attention research, the following conclusions can be drawn.

1. Attentional resources are finite and cannot be allocated to multiple locations or objects concurrently.
2. Allocation of attention to a specific location can be modulated by a cue such that distractions from other task-irrelevant objects in a visual field can be minimised.
3. By cueing a part, the whole object is brought under the focus of attention and attention spreads over the entire space occupied by that object.
4. Competition between individual objects for attentional resources can be reduced by perceptually grouping discrete objects in the visual field.
5. However, the identity of individual elements in a perceptual group is influenced by the identity of the perceptual group as a whole.
6. Further, the biological and social importance associated with some perceptual groups is processed automatically further, modulating the allocation of attention and performance on experimental tasks; this can occur even when this meaning is completely task-irrelevant.

In summary, when a target is searched in space, target identification can be enhanced if multiple locations or multiple objects can be sampled concurrently. However, with finite spatial attentional resources this is a challenge. Therefore the presence of a cue signalling the target location is beneficial. Although the attentional system is committed to accomplishing current goals it is also vigilant about salient information presented in the visual field. The presence of socially- and biologically-important stimuli can divert attentional resources from the primary task and target location. However, this might not be the case if the target location is known, so monitoring different locations is unnecessary. When narrowly focused on a given location, then, spatial attention might not be in a ‘capturable’ state.

Even in a task in which spatial attention is unlikely to be captured by a meaningful stimulus, irrelevant stimuli could nevertheless influence performance if they capture central attention (e.g., Folk, Leber, & Egeth, 2008). Central attention is proposed to be required for carrying out higher order mental functions like decision making and response selection (Johnston, McCann & Remington, 1992). In the present study I examine whether a stimulus with meaning established outside the experimental context is capable of capturing central attention when the distribution of spatial attention is controlled by a fixed target location. To accomplish these goals the rapid serial visual search presentation paradigm (RSVP paradigm for short) was employed.

1.9 Description of the RSVP Paradigm

In the RSVP paradigm (Potter & Levy, 1969), stimuli are presented sequentially at the same location for a very limited duration (e.g., 100 ms; Dux & Marois, 2009). Two standard observations are made in this paradigm. First, when subjects are required to report the identity of two pre-specified targets (T1 and T2), T1 accuracy is generally high and invariant across T1-T2 lag. T2 accuracy, however, is impaired, especially when T2 appears in close temporal proximity to T1 except when presented immediately after it. This phenomenon is known as the attentional blink (AB; Raymond, Shapiro, & Arnell, 1992) and the impairment lasts for about 500 ms, after which T2 identification is not impaired following the identification of T1. However, when T2 is presented immediately after T1 then T2 accuracy is not impaired, an effect referred to as lag-1 sparing. AB can be used as a measure of the extent to which a given stimulus can capture central attention. Of the various theories proposed to account for attentional blink two theories main theories are describe here.

1.10 Inhibition Model

Raymond et al. (1992) proposed that confusion between target features and distractor features is prevented by a suppression mechanism. This mechanism prevents distractors following T1 from being processed so that T1 representation and identification are not disrupted. This process lasts for approximately 500 ms so when T2 is presented in close temporal proximity to T1, accuracy is severely impaired because the attentional system, acting as a gate, remains closed until the completion of T1 processing. This period during which attention resources are unavailable for processing T2 is the AB.

1.11 Bottleneck Model

Chun and Potter (1995) proposed that although transient representations of all items presented in an RSVP stream can be formed, a more consolidated representation is required to be able to make an overt response to a target. However, the stage of consolidating a representation is conceptualized as a bottleneck stage of processing such that only one target can be processed at a time. If consolidation of a representation of T1 is in progress, processing of T2 is postponed. With increased delay, the momentary representation of T2 begins to decay and is vulnerable to interference (backward masking) from items presented immediately after, leading to impaired T2 identification. The duration over which a consolidated representation of T2 cannot be formed is the AB.

In summary, T2 identification can be impaired because an attentional mechanism inhibits the processing of a second target before the completion of the processing of T1. T2 identification can also be impaired because attentional resources are drained during the processing of T1 and are therefore temporarily unavailable. For the purpose of the present study, the limitation in processing T2 induced by processing T1 will be described as a limitation in central attention needed for performing some aspect of target processing (Chun & Potter, 1995; Jolicoeur, Dell'Acqua, & Crebolder, 2001). Central attention is conceptualised as the attentional filter that monitors and limits concurrent processing of resources demanding higher order mental functions like decision making and response selection (Johnston et al., 1992).

1.12 Review of Findings from the RSVP Paradigm

Central attention capture has been investigated in a number of contexts. Relevant to the present study are those that examine the spread of the focus of attention using the RSVP paradigm, studies that examine central attention capture by task-irrelevant stimuli, and studies examining central attention capture by affective or emotional stimuli.

1.12.1 Spread of the focus of attention. Jefferies and Di Lollo (2009) observed that the focus of attention was spread in a way that encompassed two RSVP streams when T1 and T2 were equally likely to appear in each of the two streams presented concurrently. After T1 was presented in one of the streams, the focus of attention began to zoom in on the target location leaving the other stream out of the focus of attention. By manipulating the interval between T1 and the item following immediately after it (SOA), Jefferies and Di Lollo monitored the rate at which the focus of attention contracted. They found that when the SOA was 100 ms, the focus of attention had contracted enough to exclude the second stream in which T1 had not appeared. As a result, T2 identification which is normally superior when presented immediately after T1 (lag one sparing) was impaired when it appeared in a stream different from T1. Thus, lag one sparing turned into a lag one deficit. Consequently, Jefferies and Di Lollo proposed that, although it might be possible to spread attention over a larger area, the focus of attention is adjusted to zoom in on the target location to maximise target identification.

Although attention is proposed to be focused narrowly at the target location in the RSVP paradigm it was observed to be captured by task-relevant features presented at the periphery away from the target location (Folk et al., 2008). Folk et al. (2008) observed that attention was captured by a distractor box within which the RSVP stream was presented when the box matched the target colour, leading to impaired target identification. However, target accuracy was enhanced when a prime (corresponding to the identity of the target letter) instead of a distractor letter was presented in the box that shared the target's colour. This indicated that the presence of the task-relevant feature in the distractor box neither reduced the resolution of the focus of attention nor spread spatial attention to the periphery, thereby allowing the prime to be processed. This in turn suggests that the impairment observed in identifying the target could not be attributed to capture of spatial attention by the distractor box; that is attentional capture in this case was proposed to be non-spatial in nature such that the distractor box captured central attention without affecting the deployment of spatial attention.

1.12.2 Central attention capture by irrelevant distractors. Even in a focused mode, attention is vulnerable to peripheral distractors sharing task-relevant features with the target (Folk et al., 2002). Subjects in this study reported a red or a green letter embedded in an RSVP stream. Additionally, in one of the frames a distractor letter was surrounded by four pound signs. The colour of one of the pound signs matched the colour of the target on some trials and on others it did not (Experiment 1). A singleton search (search for a unique item in the stream) could be carried out on trials on which the target letter was embedded among grey letters. However, on trials on which the same red or green target letter was presented among distractors that appeared in four different colours, subjects had to carry out a feature search for the one item in the target colour. Because the distractors all had different identities, the target could only be determined by attending to the pre-specified feature (i.e., the relevant colour). In Experiment 2, Folk et al. observed that target accuracy was impaired by the presence of peripheral distractors irrespective of whether or not the colour matched the target colour when a singleton search was carried out. On the other hand, only peripheral distractors matching the target colour interfered with target accuracy when a feature search was carried out. In Experiment 4 the pound signs were replaced by small squares, one of which shared the target colour. Folk et al. observed that in this case attention shifted from the location of the RSVP stream to the location of the peripherally-located small square sharing the target colour. A prime presented within the square sharing the target colour enhanced target accuracy showing that even in a focused mode attention remains vulnerable to any distractor sharing target characteristics. Similarly, unique distractors defined on a dimension (colour) different from the target-defining dimension (size) can capture central attention impairing target identification (Dalton & Lavie, 2006). Contrary to this finding Maki and Mebane (2006) found that colour alone was not enough to induce an AB in a single target identification task. The target (T2) in their study was a meaningful word in black and the distractors consisted of non-letter strings equal in length to the target word, also in black. T1 (not required to be reported) could be any one of the following: a meaningful word in red, a string of consonants in red, a red false letter string, a black false letter string, or a red string of digits. The results showed that the largest AB was observed on the trials on which T1 was a meaningful word in red followed by a consonant string in red. No AB was observed on the trials on which the distractor was a non-letter string in red. Thus, although the presence of unique items in the stream can engage attention (Dalton & Lavie, 2006; Folk et al., 2002; 2008; Ghorashi, Zuvic, Visser & Di Lollo, 2003;), the extent of the similarity between the distractors and the target determines whether or not AB will be induced by such attention capture (Maki & Mebane, 2006). That is, greater similarities between a target and the distractors increases the requirement for central attention to distinguish the distractor from the target, which in turn increases the target identification deficit.

1.12.3 Central attention capture by affective stimuli and faces. Like spatial attention, central attention is observed to be modulated by the presence of emotional words or faces. Impaired T2 (letter) identification was observed when T1 was a sad face or an angry face (de Jong, Koster, van Wees, & Martens, 2010). This study indicates that emotional faces are special such that they can capture central attention in a way that is detrimental to the identification of a second target even when the second target belongs to a different category. Emotion can be extracted from minimalistic information like schematic faces. Maratos (2011) showed that angry schematic faces induced greater AB or greater impairment in T2 identification at shorter lags when compared to faces depicting other emotions, but the recovery was also faster (Maratos, 2011) when angry faces were used. In the same study, AB induced by happy faces persisted for a longer duration. Important to this discussion are the findings of the studies showing that AB is also induced when a to-be-ignored T1 is a negative picture (Most et al, 2005), emotionally arousing picture (Most et al., 2007), sexually provocative word (Arnell et al., 2007), or taboo word (Stein, Zwickel, Kitzmantel, Ritter & Schneider, 2010). In these studies, subjects were required to report a single target and the emotional content of the picture (Most et al., 2005; Most et al., 2007) or the words (Arnell, et al., 2007; Stein et al., 2010), was irrelevant to the task at hand. Nevertheless task irrelevant emotional faces and arousing words captured central attention in a way that was detrimental to identification of a target presented in close temporal proximity to these stimuli. The researchers therefore argued that processing of arousing stimuli or emotional faces is prioritised over other neutral stimuli irrespective of task relevance, thereby interfering with the identification of a target presented later in the stream.

Additionally, other studies report better T2 identification when T2 is an emotional word (Anderson, 2005; Anderson & Phelp, 2001), angry or happy face (de Jong, Koster, van Wees, & Martens, 2009; Mack, Pappas, Silvermann, & Gay, 2002; Maratos, Mogg & Bradley, 2008; Milders, Hietanen, Jukka, Leppänen, & Braun, 2011; Miyazawa & Iwasaki, 2010; Musch, Engel, & Schneider, 2012). The results of these studies indicate that emotional faces and arousing words can be processed even when central attention is engaged in the processing of another target. Prioritised processing of emotional faces or arousing words may be facilitated by specific brain structures like the amygdala as was observed by Anderson & Phelps (2001). In their study superior identification of an emotionally arousing second target word was not observed in individuals with damage to the amygdala. Landau and Bentin (2008) proposed that perceptual salience of faces makes them immune to an AB that is induced by other non-face targets serving as T1. Superior processing of emotional faces when presented in close temporal proximity to T1 was not limited to those with increased sensitivity to the emotion of faces (such as individuals with social anxiety; de Jong et al., 2009). Researchers observing superior processing of angry faces or threat-related stimuli argue that due to their evolutionary significance attentional resources might be preferentially allocated to these stimuli over other neutral ones (Maratos et al., 2008). Additionally, studies observing superior happy face processing propose that happy faces require few attentional resources and therefore allow processing of other stimuli (see Srivastava & Srinivasan, 2010, Experiment 1) or can be processed when central attention is engaged in the processing of another target (see Mack et al., 2002; Miyazawa & Iwasaki, 2010; Srivastava & Srinivasan, 2010, Experiment 2). In summary these studies indicate that emotional faces and words are perceptually salient, and might be processed by specialized brain structures and therefore unaffected by the temporary attention deficit observed due to T1 processing in the RSVP paradigm.

Although, the review of literature provides compelling evidence indicating prioritised processing of emotional face and arousing words there is a growing body of studies that indicate that faces might not be that special. Awh et al. (2004) showed that interference from faces requiring global processing can be avoided when the subsequent target identification can be carried with feature processing. Much et al. (2012) observed that a face serving as T2 could be detected with greater accuracy when T1 and T2 could be easily discriminated. Further, in the same study when distractors were highly similar to the targets T2 accuracy was impaired to a greater extent. Barnard, Scott, Taylor, May and Knightley (2004) observed that the ability to determine whether a word referred to a paid occupation or not (waitress) was impaired only when a to-be-ignored T1 word was also a word that referred to a role performed by individuals (tourist). This impairment was not observed when T1 was a word from a different semantic category like ‘television’ or ‘mountain’. Barnard et al. (2004) proposed that interference from T1 is eminent when T1 and T2 belong to the same schema that has been adopted to identify the target words. Similarly, Huang, Baddeley, and Young (2008) observed that emotional words captured central attention only when semantic processing of these words was necessary to disregard them as non-targets. Sy and Giesbrecht (2009) also observed that the emotional valence of the faces did not affect AB when gender was the task-relevant dimension. These findings make a strong case against the claim that processing of emotional faces and arousing words is prioritised over competing neutral stimuli.

Three main conclusions can be drawn from this review. First, the spread of attention to a larger area is restricted in the RSVP paradigm to maximise target identification under such high temporal constraints. Second, AB can be induced by unique distractors, or distractors sharing task-relevant features. Third, like spatial attention, deployment of central attention is modulated by affective words or faces.

The RSVP paradigm is customarily used to study deployment of attention across time and to measure the time taken to analyze and encode information when a sequence of items is presented in a specified location for a very short duration (Dux & Marois, 2009). I believe, for three reasons, that this paradigm is also suitable for examining the question of whether meaning can capture central attention when it is maintained in a focused mode. First, as has been shown in this paradigm, the focus of attention is maintained narrowly over the target location to maximise target identification which is an important requirement in the present study. Additionally, Jolicoeur et al. (2001) have proposed that AB induced by the processing of T1 is a measure of central attention capture. Therefore, by monitoring second target accuracy using this paradigm it is possible to examine the availability of central attention for second target processing while controlling for the distribution of spatial attention. Second, the onset of the distractors can be manipulated thereby discouraging subjects from developing strategies to counteract the impact of the distractors. Third, by monitoring target accuracy as a function of the delay between the onset of the distractors and the onset of the target it is possible to monitor the rate at which central attention can be redirected from processing the distractors to processing the target; if meaningful stimuli are more effective in engaging central attention than meaningless stimuli, the availability of central attention for processing the target will be delayed.

2. Present Study

In the attentional capture literature, spatial attention capture examines the challenges faced when multiple objects are required to be processed concurrently while searching for a target in space. Central attentional capture, in contrast, examines the challenges faced when required to carry out resource demanding stages of two tasks, concurrently. Johnston et al. (1995) pointed out that target selection in the spatial cueing paradigm is accomplished by the attentional system which limits parallel perceptual processing of multiple stimuli, which is proposed to take place in the early stages of processing in a task. On the other hand, target selection in the RSVP paradigm (Jolicoeur et al., 2001) is accomplished by central attention which limits parallel processing of higher order mental functions like response selection and operates at later stages of processing. As reviewed above, previous studies indicate that task-irrelevant yet meaningful stimuli (Eastwood et al., 2003) can capture attention, impairing target selection on spatial tasks even when these stimuli are presented at a location outside the target location (Forster & Lavie, 2008; Lavie et al., 2003), thereby showing that limited attentional resources cannot be distributed to multiple locations or objects concurrently. Task-irrelevant stimuli appearing in the periphery (Folk et al., 2002, 2008), emotional words (Arnell et al., 2007) or pictures (Maratos, 2011; Most et al., 2005; Most et al., 2007) are also observed to engage central attentional resources in a way that impairs target identification. However, in the studies described in the literature review, arousing words (see Arnell, et al., 2007) and emotional or arousing pictures (Maratos, 2011; Most et al., 2005; Most et al., 2007) were within the focus of attention and were also part of the relevant stimulus set. That is, some processing of these task-irrelevant items was necessary to make decisions about whether or not these were targets. Three interesting questions emerge from the review of the attention capture literature.

First, can the meaning associated with a stimulus outside the experimental context capture central attention in the same way as such meaningful stimuli have been shown to capture spatial attention?

Second, if so, can pre-existing meaning enhance the effectiveness of a distractor in capturing central attention over and above the capture observed for distractors that share a task-relevant feature of the target?

Third, how is processing of the item accompanying a peripheral distractor

Table 1: Research questions addressed in each experiment

Experiment number	Research question
Experiment 1	Does the identity of the perceptual group interfere with a visual search task when the target is embedded within a meaningful perceptual group?
Experiment 2	Can meaning capture central attention when it is maintained in a focused mode?
Experiment 3	What is processed when peripheral elements group meaningfully?
Experiment 4	Is it possible to report the identity of a target when it is embedded within a meaningful perceptual group?
Experiment 4a	Can a Gestalt face be perceived from the stimulus used?
Experiment 5	Can the focus of attention be broadened by altering the size of the letters presented in the RSVP stream?
Experiment 6	Can the focus of attention be broadened and the peripheral elements grouped meaningfully be brought under the focus of attention by presenting a red hexagon prior to the presentation of the perceptual group?
Experiment 7	Can central attention be disengaged from its focused mode by interrupting the RSVP stream?

influenced when central attention is captured by the distractor?

In the present study characteristics of peripheral elements such as colour and meaning (peripheral elements grouped to form a face or not) were manipulated orthogonally to examine how task-relevance and pre-existing meaning modulate the allocation of central attention when spatial attention is carefully controlled. Six experiments examining central attention and one experiment examining spatial attention were carried out to examine the questions outlined in the preceding section; please refer to Table 1 for the details of the research question addressed in each experiment.

3. Experiment 1: Can stimuli created in the present study replicate the findings of previous spatial attention studies?

Kimchi (2009) proposed that the visual field is usually organized into discrete objects on the basis of bottom up inputs or Gestalt grouping principles. Scholl (2001) proposed that the organization of the visual field into objects is important as these objects then serve as *units* influencing the way in which attention functions. Attention is allocated to the objects as a whole rather than to individual elements present within the object. Consequently, greater difficulty is observed in identifying a target that forms part of an object, as was observed by Wolfe, Friedman-Hill, and Bilsky (1994). This paradigm was employed in Experiment 1 to test whether a Gestalt face that was created by arranging two straight lines and a curve to look like a face can capture spatial attention and impair target identification when the target is embedded within the face. One hypothesis was tested in this experiment.

3.1 Hypothesis 1

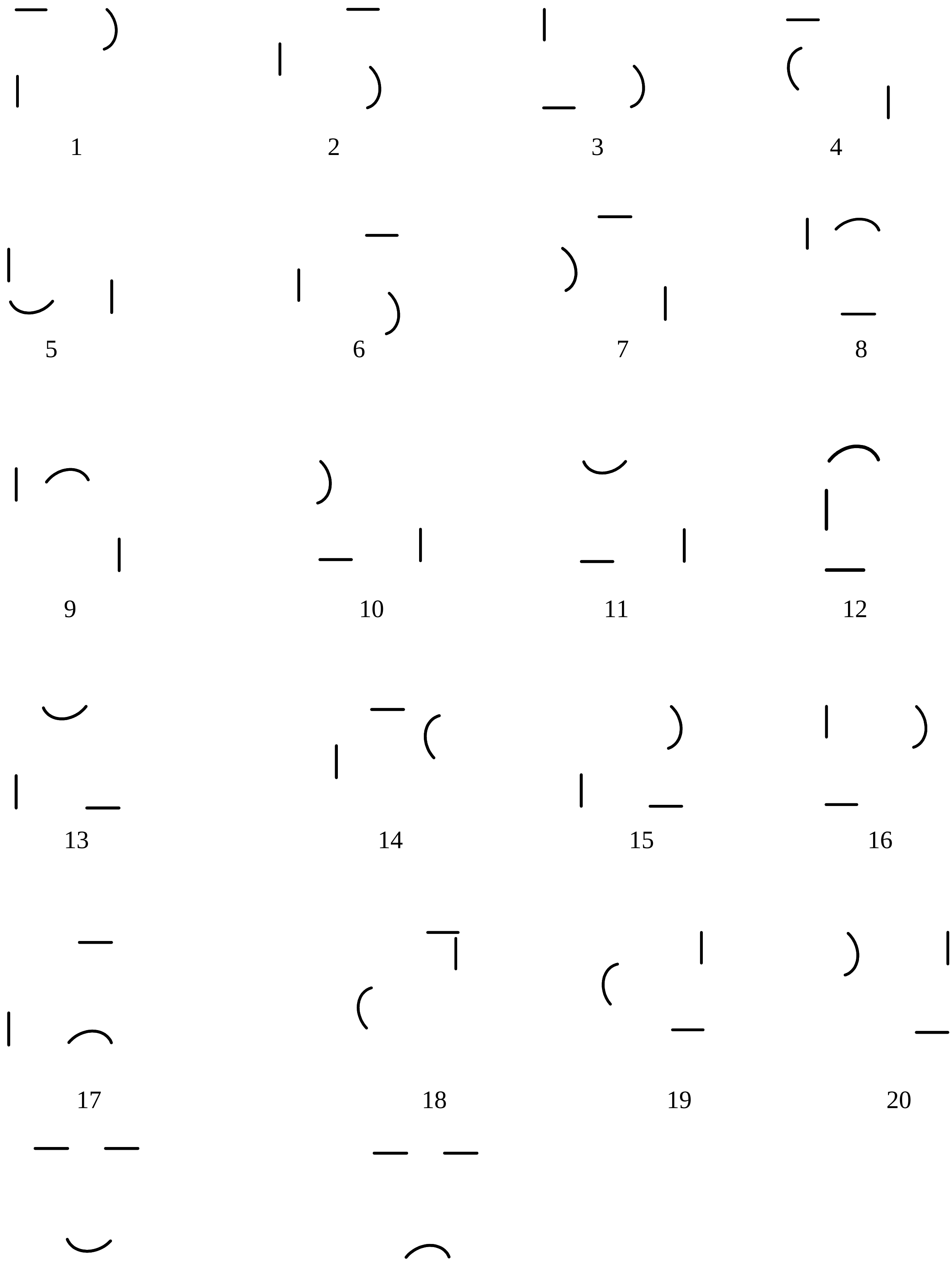
If the identity of the perceptual group is processed then target identification will be impaired when the target is embedded in an emotional face.

3.2 Methods

3.2.1 Subjects. Sixteen students from an undergraduate student research participant pool were recruited to volunteer for the experiment. Subjects were required to have normal or corrected-to-normal vision. Subjects received a bonus credit for a psychology course.

3.2.2 Stimulus and apparatus. Apple iMac computers were used to conduct all the experiments reported in the present study. The experiments were programmed using E-Prime 2.0 software. The screen resolution of the monitors was 1920 X 1200 pixels and the vertical refresh rate was 60 Hz. The perceptual group stimuli used in the present study were created with two straight lines and a curve. In the rest of the manuscript the two straight lines and the curve will be referred to as peripheral elements. Each of the two straight lines was 1.4° long and 0.2° wide. The two edges of the curves were 1.7° apart and the width of the curve was .2°. The perceptual groups were created by drawing an imaginary square which was 4.2° long and each side of the square was divided into three parts. One peripheral element could be placed in any one of these three positions on each side, with the constraints that no more than one element could appear on each side, and three sides were to be occupied by an element. The position occupied on each side was randomly generated by the computer. Thirty arrangements were created by placing the three peripheral elements in the position generated by the computer. The perceptual groups were created by the computer by randomly generating arrangements of two lines and a curve in order to prevent creating groups that might resemble other meaningful groups like a house or a cup. After discarding arrangements that resembled a face, twenty

Figure 2: Images used in the experiment



different arrangements of peripheral elements were chosen to serve as distractors that did not group meaningfully or resemble other familiar objects. The face was created by placing the two straight lines on the top and the curve at the bottom. The curve facing upwards formed a happy Gestalt face and when it faced downwards it formed a sad Gestalt face. The images were created in Microsoft PowerPoint and exported as a bitmap file. Please refer to Figure 2 for images of the perceptual groups or stimuli used in the study.

3.2.3 Procedure and design. The experiment began with a training block in which a meaningless perceptual group was assigned to each subject and served as the target. Subjects were allowed to study the perceptual group as long as they wanted. On subsequent trials subjects indicated whether the image shown on the screen was the target assigned to them or not. After achieving 100% accuracy on three consecutive blocks, the experimental session began. Subjects carried out two different tasks in the experimental session. Subjects completed 125 experimental trials (5 blocks of 25 trials) of a perceptual group identification task followed by 125 trials (5 blocks of 25 trials) of a letter identification task. The computer screen was divided into 12 imaginary rectangles 18° wide and 11° long. Five perceptual groups were randomly presented at the center of one of these 12 imaginary boxes. Additionally, on 50% of the trials in a block an emotional face was presented along with four other meaningless perceptual groups. Whether an emotional face was present or absent was randomized within blocks.

In the perceptual group identification task, subjects were instructed to press ‘1’ to indicate the presence of the target perceptual group and ‘2’ to indicate the absence of the same. Subjects were required to respond as quickly and accurately as possible. Please

Figure 3: Stimulus display target perceptual group search task in Experiment 1

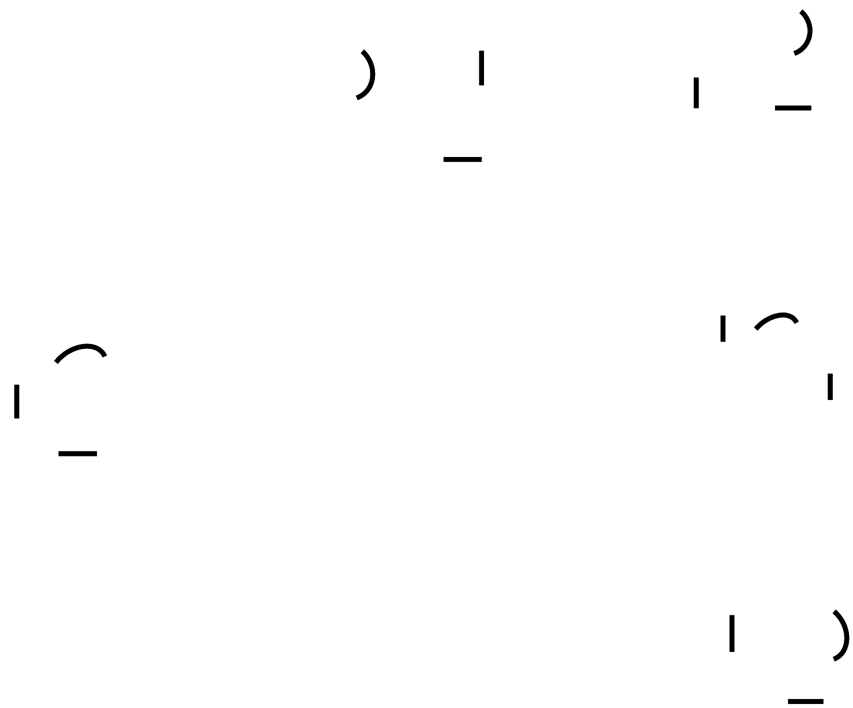
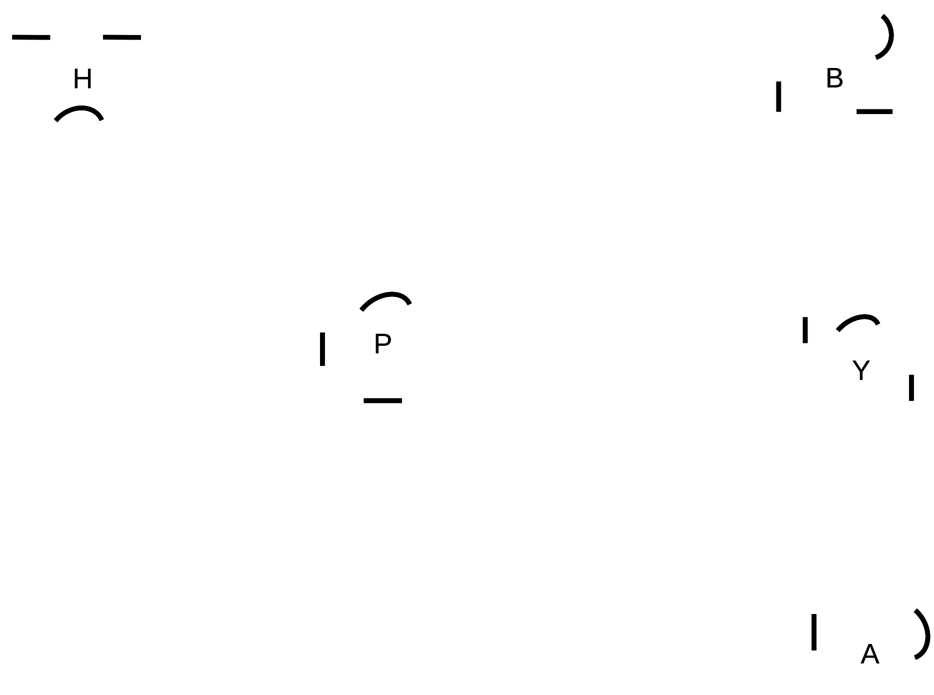


Figure 4: Stimulus display on the letter search task in Experiment 1



refer to Figure 3 for examples of the stimulus display for the perceptual group identification task.

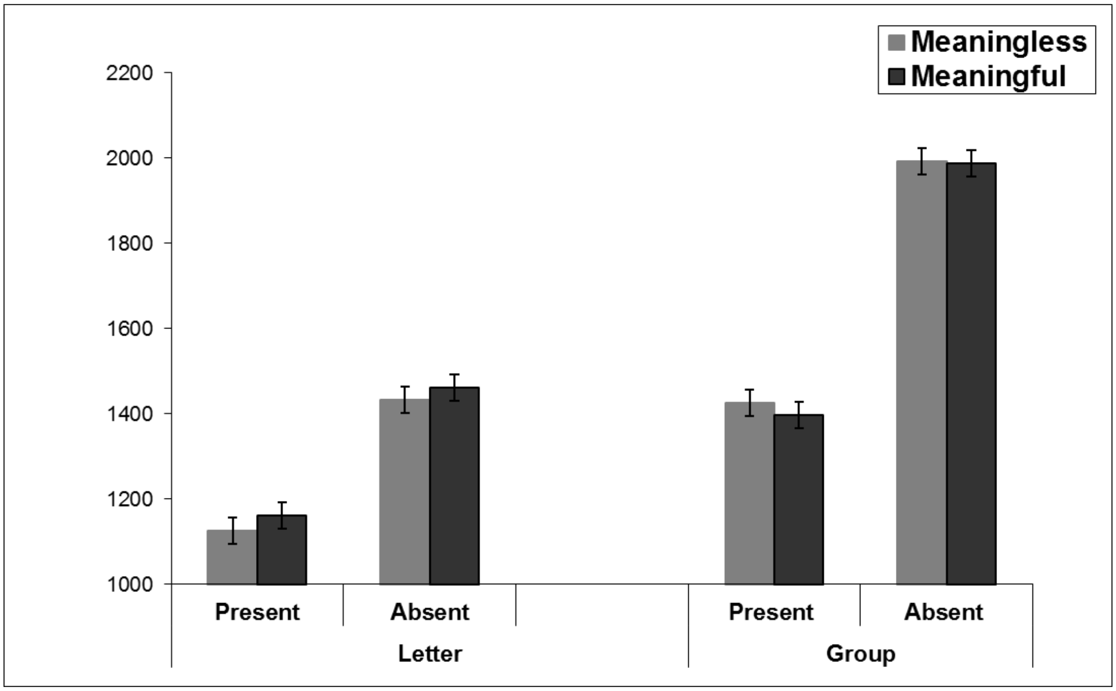
In the letter identification task each subject was assigned a target letter and subjects were instructed to quickly and accurately press ‘1’ when target was present and ‘2’ when the target letter was absent. Further, on each trial one perceptual group was presented randomly within five of the 12 possible locations. A letter was present within each of the perceptual groups presented in the stimulus display. Two independent variables were manipulated: presence/absence of the target and presence or absence of the emotional face in the stimulus display, coded as meaningful/meaningless respectively, resulting in a factorial design with four conditions, *target present meaningful, target absent meaningful, target present meaningless* and *target absent meaningless.* It is important to note that on the *target present meaningful* trials the target letter was always presented within the Gestalt face. This allowed me to examine whether the identity of the target letter is difficult to report when it is embedded within a face as observed by Eastwood et al. (2003). The four trial types were presented with equal frequency, randomized within each block. The time taken to report the presence or absence of the target (RT) was the dependent variable. Please refer to Figure 4 for examples of the stimulus display in the letter identification task.

3.3 Results

Trials with responses that were outliers were identified by calculating the mean and the standard deviation for each cell for each subject. Each RT observation was then converted into a z score. If the z value was higher or lower than the value of a criterion (C_n), the trial was excluded from the data set. C_n is a criterion value adjusted for the sample size (n) as estimated from Monte Carlo simulations and corresponds to the number of observations under consideration. The different estimates of C_n are reported in Van Selst and Jolicœur (1994), but for cells in which n > 50 (as was the case in the present study), $C_n = \pm 3.5$. After the outliers were excluded the mean and the standard deviation for each cell were recalculated and the entire process was repeated. This analysis was carried out repeatedly until none of the z-scores exceeded the value of the criterion. After excluding 224 trials that were outliers and trials on which an incorrect response was made, 3076 trials were included in the letter task analysis. In the group identification task, 218 trials were excluded and 3083 trials were included in the analysis.

Target type (2 levels), target presence (2 levels), and meaning (2 levels) were the independent variables and RT was the dependent variable in a 2 X 2 X 2 repeated measures ANOVA. The main effect of target type was significant, $F(1, 16) = 34.8$, $MSE = 161180.3$, $p < .001$, $\eta_p^2 = .69$, indicating that search for the target letter was faster (1295 ms) than the perceptual group (1701 ms). The main effect of the presence of the target was significant, $F(1, 16) =326$, $MSE = 20310$, $p > .001$, $\eta_p^2 = .95$, indicating that less time was taken to report the presence (1277 ms) of the target than to report its absence (1718 ms). The main effect of meaning was not significant, $F < 1$, indicating that the presence or absence of an emotional face did not interfere with target search overall. The two-way interaction between target presence and target type was significant, $F(1, 16) =58.9$, $MSE = 10897.1$, $p > .001$, $\eta_p^2 = .79$, indicating that a greater time difference between the letter task and the perceptual group task was observed when the target was absent than when it was present. No other interactions or main effects were significant, all *Fs* < 2.9 and *p*s > than .10. Please refer to Figure 5 for the mean RTs as a function of

Figure 5: Mean response time as a function of target type, target presence and meaning



target type, presence of target, and meaning.

The important question asked in this experiment is whether the presence of Gestalt faces as represented in this study captures spatial attention, thereby impairing target identification. Because this was only expected to occur in the letter identification task (in which the target letter is embedded within a meaningful or meaningless perceptual group), some additional analyses were carried out with the letter identification task. Analysis of the RT in the letter identification task yielded a significant main effect of meaning, $F(1, 16) = 6.98$, $MSE = 2569$, $p < .001$, $\eta_p^2 = .30$, indicating that the time taken to search for the target letter was greater (1311 ms) when the perceptual group formed a face than when it did not form a face (1278 ms). The main effect of target presence was significant, $F(1, 16) = 195$, $MSE = 8018$, $p > .001$, $\eta_p^2 = .92$, indicating that the time taken to report the presence of the target (1142 ms) was faster than when the target was absent (1442). The interaction between meaning and target presence was not significant, $F < 1$.

Two t-tests were carried out to examine whether the presence or absence of a face interfered with subjects' ability to search for the target. A significant difference in the time taken to report the absence of a target was observed when a non-target was embedded in the emotional face, $t(16) = 2.31$, $p <.03$. A marginally significant difference in the time taken to report the presence of a target was observed when the target letter was embedded in an emotional face, $t(16) = 2.09$, $p <.06$.

3.3.1 Analysis of errors. The main effect of target presence was significant $F(1, 16) = 82.8$, $MSE = .001$, $p > .001$, $\eta_p^2 = .84$ showing that target present trials were more error prone than target absent trials. The two way interaction between meaning and presence of target was significant, $F(1, 16) = 4.42$, $MSE = .001$, $p > .52$, $\eta_p^2 = .22$, 6% more errors were made on meaningful trials when the target was absent whereas only 1% more errors were made on meaningful trials when the target was present compared to meaningless trials. No other main effect or interaction were significant all Fs < 1.7, ps > .20.

3.4 Discussion

Consistent with the claims made in the literature (Eastwood et al. 2003, Suzuki & Cavanagh, 1995), the results of Experiment 1 showed the Gestalt face created from a particular grouping of the two straight lines and the curve captured spatial attention in a visual search task thereby interfering with target detection. A comparison of the mean RTs on both target absent and present trials suggests that the emotional faces interfered with target identification on the letter search task. The presence of the face in the stimulus display captured spatial attention but attention was probably allocated to the face as a whole instead of to the letter embedded within the face. Consequently, more time was required to determine whether the letter embedded within the face was a target or not. The identity of the target letter was not obscured in the same way when embedded in the non-face perceptual groups and so it could be detected faster on *meaningless* trials than on the *meaningful* trials. Important to note, on trials in which the Gestalt face and the target was present the target was presented within the face. However, these trials were presented randomly with other trials on which either the target was presented within a non-face perceptual group or the face was present but the target was absent. So adopting a strategy to locate the face first and then determining whether the centrally-located letter is the target would be useful on 25% of the trials only. Nevertheless, even if the face acted as cue directing attention to the target location, the time taken to report the target when present within the face should be shorter than when the target was presented within a non-face perceptual group which was not the case in this experiment.

In the perceptual group task the identity of the perceptual group was distinct from that of the Gestalt face therefore interference from the face could be avoided. As observed by Eastwood et al. (2008) the perceptual group task served as a control showing that interference in the letter task was observed because the identity of the target letter was embedded within the identity of the Gestalt face as a whole.

In the next six experiments, the Gestalt faces shown to capture spatial attention in Experiment 1 were employed to examine whether they could also capture central attention in a way that would be detrimental to target identification. The experimental paradigm was altered for the remaining experiments and the RSVP paradigm employed by Folk et al. (2008) was modified to examine the research questions, as discussed in the next section.

4 General Methods

Folk et al. (2008) showed that in an RSVP sequence, task-irrelevant peripheral distractors captured attention in a way that was detrimental to the identification of a single target (customarily referred to as T2) when T2 was presented in close temporal proximity to the peripheral distractor box. However, it is unknown whether meaning formed outside the experimental context can capture central attention in the same way as meaning can capture spatial attention. The paradigm of Folk et al. (2008) was modified to test this question. In Folk et al.'s study subjects reported the identity of a single red or green target letter, varied between blocks. The target letter was embedded in an RSVP sequence of grey distractor letters presented within a grey coloured box. The colour of the box was changed to red or green, which took the place of T1. The colour of the distractor box was manipulated to examine the extent to which the presence of task relevant features in the box led to central attention capture[4]. Subjects were proposed to have adopted a singleton search in this case because the target was a unique item in the sequence; consequently, target identification was impaired at short temporal lags when the colour of the distractor box changed from grey to red or green. In the present study subjects similarly reported the identity of a red letter embedded in a sequence of black distractor letters displayed against a white background of items presented in an RSVP sequence. Further, one of the distractor letters was embedded within one of the perceptual groups from Experiment 1 instead of the distractor box. Please refer to Figure 2 for images of the perceptual groups used. To prevent biasing subjects from organising the stimulus display as perceptual units, and because faces were shown on only half of the trials, the perceptual groups that served as the distractor were described as two straight lines and a curve to the subjects. Because the basic experimental paradigm employed in the next five experiments remained unaltered, the details of the experimental design are discussed in the next section. The manipulations used to test specific questions in individual experiments are discussed in the methods section of the respective experiments.

4.1 Subjects. All subjects were recruited from the psychology participant pool at the University of Regina. All subjects received a bonus credit for a psychology course taken

[4] Attention captured by the red distractor box was referred to as "non-spatial contingent capture" of attention by Folk et al. (2008) however to be consistent with the terminology adopted in the present context I have referred to it as central attention.

at the University of Regina.

4.2 Stimulus and apparatus. Each letter in the RSVP sequence was presented at the centre of an imaginary box that was 19.5° wide and 12.3° long. A red fixation cross 1.3° long and 1.4° wide was presented at the beginning of each trial. Twenty uppercase black letters drawn randomly from the English alphabet excluding the letters I, J, N, O, V, W and Z were presented against a white background at a rate of 1 item per 84 ms in an RSVP sequence. The letters were presented in bold Times New Roman font and the size of the font was 36 points. The height of each letter was 1° and the width was .7°. Twenty letters were presented in a single stream at the centre of the screen. Subjects reported the identity of a unique red target letter in a stream of black letters (i.e., the target could be searched by adopting a singleton search mode). Additionally, one of the distractor letters in the series presented prior to the target letter was surrounded by two straight lines and a curve (the peripheral elements). The two straight lines were presented 1.4° degrees from the top or the bottom or the left or the right edge of the centrally-located distractor letter. The curve was presented 1.4° away from the top or the bottom or the left or the right edge of the distractor letter. The distractor letter surrounded by the peripheral elements served in place of T1 in the standard attentional blink paradigm; because it was a distractor, subjects were not instructed to report this letter. The presentation of the Gestalt faces and non- face groups formed from the specific arrangement of the peripheral elements was manipulated within blocks. Further, the peripheral elements matched the colour of the distractor letter (black) on some trials and on others the peripheral elements matched the colour of the target (red).

4.3 Procedure and design. Each experiment consisted of two blocks, namely practice and experimental. No peripheral elements were presented in the *practice* blocks, which served as a baseline against which to compare the effect of the presence of the distractors; lag was dummy coded for these trials. The peripheral elements were presented in the experimental block. The factorial manipulation of meaning (whether or not the peripheral elements formed a face) and relevance (whether or not the peripheral elements matched the red target letter) resulted in four trials types. On *meaningless irrelevant* trials the distractor letter was surrounded by black peripheral elements not forming a face. *Meaningful irrelevant* trials were similar to the *meaningless irrelevant* trials except the peripheral elements formed a face. The *meaningless relevant* condition was identical to the *meaningless irrelevant* trials, except the peripheral elements were red in colour. Finally, the *meaningful relevant* condition was identical to the *meaningless relevant* trials except that the peripheral elements formed a face. Subjects were explicitly instructed to ignore the peripheral elements when present.

Each experiment began with 20 practice trials followed by eight blocks of experimental trials. Each experimental block consisted of 40 trials. Four blocks of irrelevant trials were presented first, followed by four blocks of relevant trials, with both levels of meaning present in each set of blocks. On task relevant trials the presence of the task-relevant colour in the peripheral elements would increase the salience of the peripheral elements and the face formed on meaningful trials. Thus, subjects would be primed to perceive the face and it would not be possible to determine whether the face was processed because the face captured central attention on its own merit or because the presence of the task relevant colour made the face more salient thereby leading to central attention capture. Therefore, task-irrelevant trials (i.e., black distractors) were presented first to examine whether the face that was formed by the special arrangements of the peripheral elements can capture central attention in the same way as faces have been observed to capture spatial attention. Each trial began with a fixation cross displayed at the centre of the screen for 500 ms in red reminding subjects that they were required to search for a red target letter. The fixation cross was followed by a blank screen for 500 ms. Thereafter, 20 letters in uppercase were presented sequentially. Each letter was presented for 42 ms, followed by a blank screen for 42 ms. At the end of the sequence subjects were required to type in the identity of the red target letter. A blank screen was presented for 1000 ms after a response was made, followed by the next trial. The peripheral elements were presented in the 7^{th} to 11^{th} position in the sequence from the fixation cross, determined randomly on each trial. The target was randomly presented in the 1st, 2nd, 5th or 8th position after the distractor position (when present); i.e., at a lag of 1, 2, 5, or 8 items. The accuracy with which the target letter was identified at each lag was recorded and served as the dependent variable. Relevance (irrelevant black vs. relevant red), meaning (meaningful face vs. meaningless non-face), and lag (1, 2, 5 and 8) were the independent variables. All factors were manipulated within subjects.

5 Experiment 2: Can Meaning Capture Central Attention?

This experiment examined whether meaning can capture central attention in a way that is detrimental to target identification. The following three hypotheses were tested:

5.1 Hypothesis 1

If peripheral elements capture central attention then target identification will be impaired more at short temporal lags than at longer temporal lags.

5.2 Hypothesis 2

If the presence of task relevant features captures central attention then target identification will be impaired to a greater extent when the peripheral elements match the target colour than when the peripheral elements do not match the target colour.

5.3 Hypothesis 3

If meaning can modulate central attention then peripheral elements grouped meaningfully will impair T2 identification to a greater extent than when these elements do not group meaningfully.

5.4 Methods

5.4.1 Subjects. Twenty six students participated in this experiment.

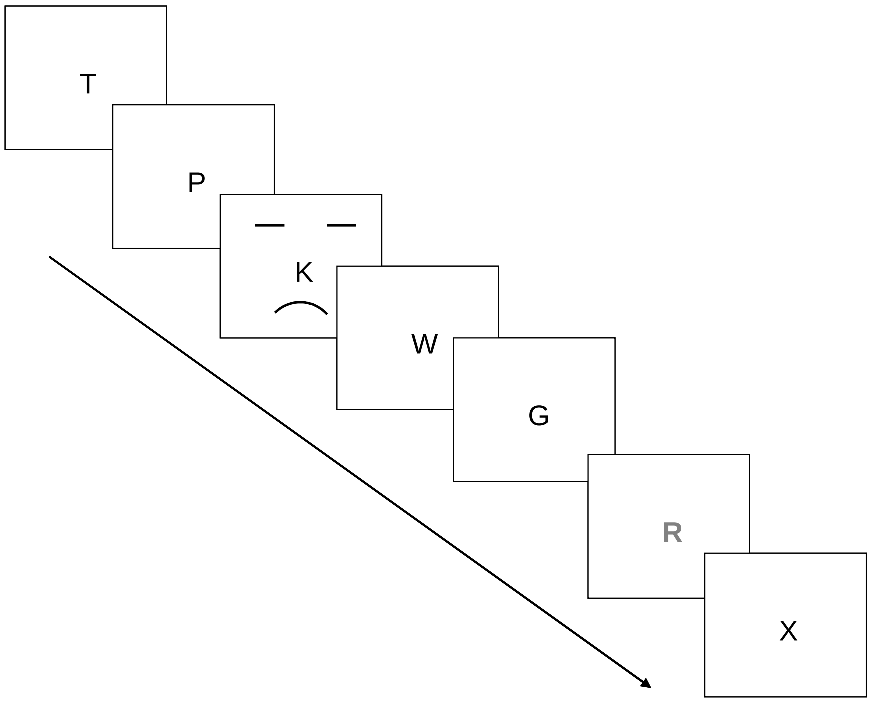
5.4.2 Procedure and Design. The experimental design was same as described in the general methods section. Please refer to Figure 6 for an example of the events on a trial on which the task-irrelevant peripheral elements formed a face.

5.5 Results

Accuracy was the dependent variable in this experiment and was scored as 0 for incorrect T2 identifications and 1 for correct T2 identifications[5]. The distribution of scores in this case is a binomial distribution in which the variance is dependent on the mean number of correct responses made. Consequently, both means and variances would vary across conditions, violating a key assumption of ANOVA. To correct for this, an arcsine transformation of the means is recommended by Howell (2002). The mean accuracy with which T2 was identified for each cell (involving 4 levels of lag, 2 levels of relevance, and 2 levels of meaning) for each subject was computed. These mean accuracy

[6]Target identification is referred to as T2 identification in the present context to be consistent with the terminology used in the RSVP literature.

Figure 6: Events on a task irrelevant meaningful trial grey target letter is presented in red in the actual experiment



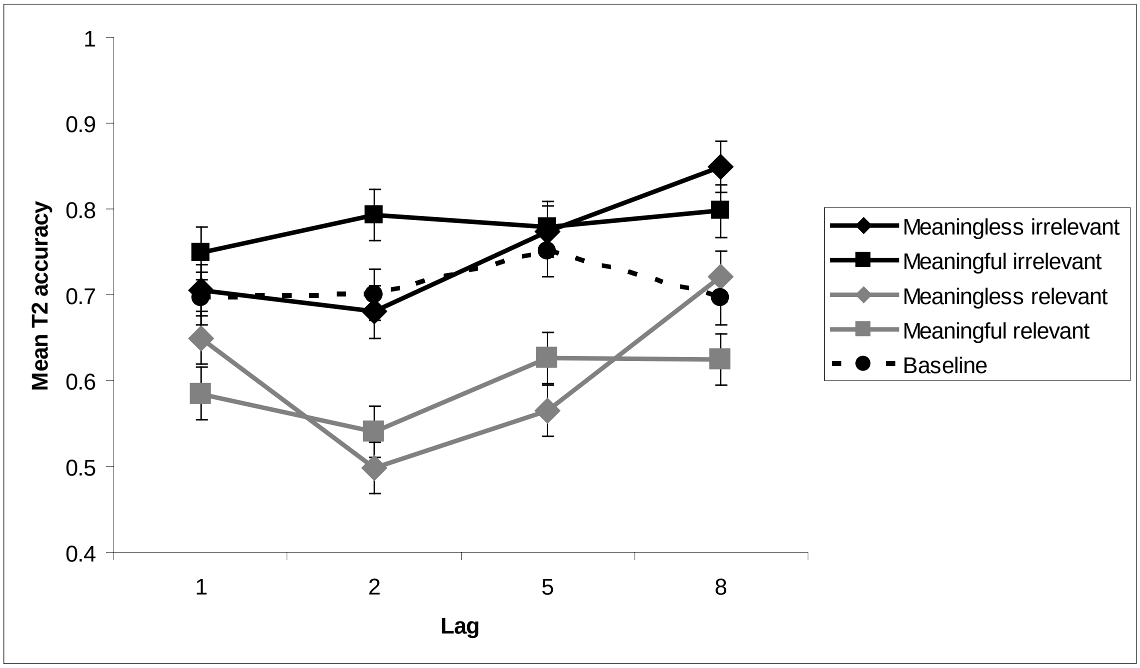
scores for each subject were transformed by employing the arcsine transformation formula in Microsoft Excel (y= arcsine × $\sqrt{p}$ where *p* is the mean of the correct responses in a cell). The transformed scores from each cell were then submitted to a repeated measures ANOVA. The scores from the baseline condition give an estimate of T2 accuracy at different lag positions in the absence of T1, but data from this condition were not included in the ANOVA so that the data could be analyzed in a factorial design. Only data from experimental trials were considered for analysis. Although both sad and happy faces were used in the meaningful condition, no interpretable and consistent differences were found between these two emotions and therefore the two emotions were averaged over in the analysis in all the experiments. A significant main effect of lag was observed, F (3, 75) = 20.7, MSE = 66.0, p < .001, η_p^2 = .45, showing that peripheral elements captured central attention in a way that was detrimental to T2 identification at short temporal lags. The main effect of relevance was significant, F(1, 25) = 150, MSE = 78.3, p < .001, η_p^2 = .86, indicating that target identification was impaired to a greater extent when the peripheral elements matched the target colour (M=.61) than when they did not (M=.71). However, T2 identification was not influenced by whether the peripheral elements formed a face (M=.66) or not (M=.67); that is, the main effect of meaning was not significant, F < 1. The interaction between relevance and meaning was not significant, F (1, 25) = 3.46, MSE = 46.55, p > .08, η_p^2 = .12, indicating that the effect of task relevance did not differ as a function of whether the peripheral elements formed a face or not. The two way interaction between meaning and lag was significant, F (3, 75) = 8.8, MSE = 60.76, p < .001, η_p^2 = .26, indicating that at shorter lags T2 identification was impaired to a greater extent when the peripheral elements did not form a face than when they did. This is opposite to what was expected. The interaction between relevance and lag was significant, F (3, 75) = 4.11, MSE = 56.28, p < .01, η_p^2 = .14, indicating that central attention was captured, leading to greater impairment in T2 identification at shorter lag for relevant distractors than for irrelevant distractors. A significant three way interaction between relevance, meaning, and lag, F(3, 75) =3. 84, MSE = 54.47, p < .01, η_p^2 = .13, indicates that task-relevant peripheral elements not forming a face impaired T2 identification to a greater extent at shorter lags than when the task relevant peripheral elements formed a face. Please refer to Figure 7 for a depiction of T2 accuracy in each of the conditions.

Data from the task relevant and irrelevant trials were analyzed separately to explore the significant three-way interaction and to examine the way in which meaning influenced T2 identification. A significant two way interaction of lag and meaning was observed on both task-irrelevant and task-relevant trials, however T2 identification was impaired to a greater extent by the presence of the peripheral elements that do not group meaningfully. Please refer to Appendix 1 for the details of the analysis. Verbal reports collected from subjects revealed that only 38% of the subjects reported seeing a face. This was surprising because each subject was exposed to 208 trials of a happy or a sad face serving in place of T1.

5.6 Discussion

Three interesting observations were made in this experiment. First, as proposed in hypothesis 1, peripheral elements captured central attention in a way that impaired T2 identification at short temporal lags more than when T2 was presented at long temporal lags. Second, as proposed in hypothesis 2, T2 identification was impaired to a greater

Figure 7: Mean T2 accuracy in Experiment 2 as a function of relevance, lag, and meaning.



extent when the peripheral elements were task-relevant than when they were task-irrelevant. However, the results of Experiment 1 did not support hypothesis 3 - T2 accuracy was impaired by the presence of the peripheral elements that did not form a face to a greater extent than the peripheral elements that formed a face. No difference was observed between T2 accuracy for the baseline condition and the irrelevant trials at any lag.

The results of Experiment 2 show that task-irrelevant peripheral elements can capture central attention in a way that induces an attentional blink at short temporal lags as measured through impaired T2 identification. The results of the present study are also consistent with the findings of other studies (e.g., Dalton & Lavie, 2006; Folk et al., 2002) showing that, even when highly focused, attention remains vulnerable to capture by distractors presented peripherally to the target location. In the present study subjects were required to search for a red target letter and the peripheral elements did not match the target specification except when they were task relevant. Subjects were explicitly instructed to ignore the two straight lines and curve that would sometimes appear with a distractor letter. However, the results show that stimuli presented in the periphery captured attention in a way that was detrimental to T2 identification, even when attention was highly focused and with conscious intention to ignore them. One possible reason the peripheral elements were attended was because subjects were able to carry out singleton search in this experiment because the target letter was a unique item among the distractor letters. In the same vein, the distractors were also singletons because no other items were similar to the peripheral elements in the sequence. Possibly, the attentional filter was set rather leniently as proposed by Folk et al. (2002), allowing any singleton to be processed and, as a result, subsequent target identification was then impaired. Further, a greater capture of central attention was observed when these elements shared the task-relevant feature (colour) than when they did not. Finally, it is also possible that the focus of attention was broadened by the presence of the peripheral distractors and, as a result, the resolution of the focus of attention was reduced and T2 identification was impaired at short temporal lags.

Although meaning interacted significantly with lag and relevance, the interaction was in the opposite direction from the prediction which proposed that peripheral elements forming a face would capture central attention in the same way as spatial attention is captured (Experiment 1; Eastwood et al., 2003; Forster & Lavie, 2008). There are several possible reasons why this outcome was not observed in this experiment. First, it is possible that faces are not special and they are as easy to ignore as meaningless stimuli when the focus of attention is maintained narrowly over the known target location. However, this explanation is contrary to observations made in Experiment 1 and other spatial attention studies that repeatedly show that faces are perceived from minimalist information like three arcs facing upward or downward (Suzuki & Cavanagh, 1995), those showing that negative emotions can be perceived from simple geometric shapes likes triangles (Watson et al., 2012), and those showing that face stimuli can be processed automatically (Vuilleumier et al., 2001) or with minimal attentional resources (Lavie et al., 2003), when they are task-irrelevant (Eastwood et al., 2003) and by individuals with brain damage (Vuilleumier & Schwartz, 2001). Further, employing the RSVP paradigm, Mack et al. (2002) showed that the capture of central attention by a target did not impair the ability to report the presence of a happy face later in the sequence, showing that faces can be processed even when central attention is engaged in the processing of a target. Second, it is possible that because faces are processed automatically (Vuilleumier et al., 2001) or with minimal attentional resources (Lavie et al., 2003) they did not draw attention away from the resource demanding letter identification task. If this was true then two outcomes were expected. T2 identification would be significantly less impaired on the meaningful trials than on the meaningless trials. Some evidence for this claim is observed in the significant two way interaction between meaning and lag showing better T2 identification on meaningful trials than on meaningless trials. Additionally, on meaningful trials the identity of the face would be extracted automatically so it would be difficult to avoid interference from the peripheral distractors although they were irrelevant to the current task. Attention captured by the peripherally-located face distractors was then expected to broaden the focus of attention, reducing its resolution and impairing T2 identification at short lags. This possibility will be explored in Experiment 3. Third, it is possible that the identity of the perceptual group was not processed because the attentional filter was set to process only red letters. Therefore, although the presence of task-relevant features (red colour) in the peripheral elements led to the deployment of attentional resources to these elements (Nieuwenstein, Chun, van der Lubbe, Ignace, & Hooge , 2005), because the characteristics of the peripheral elements did not fit the target specification, the *input filter* (as described by Di Lollo, Kawahara, Ghorashi & Enns, 2005) that was adopted to prevent processing of distractors hindered further processing of the peripheral elements. If so, the identity (face or non-face) of the perceptual group formed from the arrangements of the peripheral elements would not be processed. Verbal reports collected at the end of the experiment revealed that only 38% of subjects were aware of the presence of the faces on the experimental trials, despite the fact these faces were presented on 208 trials. Subjects also reported that the task was very demanding and that they tried their best to focus on the letters and might have missed other stimuli that might have been present. Finally, it is possible that the meaning did capture attention but that the effects were transient and dissipated before the presentation of T2. Therefore, the impact of meaning was not reflected on the accuracy with which T2 was identified. Further, the letter presented with the peripheral elements was a distractor letter and subjects were not required to report its identity. As such, subjects did not process the identity of the perceptual group and meaning did not impair T2 identification.

In summary, the results of Experiment 2 indicate that the presence of peripheral elements captured central attention in a way that impaired identification of a target presented in close temporal proximity but only when the peripheral elements shared task-relevant features with the target such as colour. However, the results of this experiment do not provide conclusive evidence of whether or not meaning can also lead to central attentional capture similar to that observed for spatial attention. In Experiment 3 the experimental design was modified to address this and also to examine whether the information presented concurrently with the peripheral distractors is processed more readily when the peripheral elements group meaninglessly (i.e., do not form a face) than when they are meaningful (i.e., form a face) as was suggested by the results of Experiment 2.

6. Experiment 3: What is Processed When Attention is Captured by Peripheral Elements?

In their Experiment 2, Folk et al. (2008) showed that T2 identification was impaired when the colour of the distractor box within which the RSVP sequence was presented briefly changed to match the colour of the target. However, when a prime was presented in the box that acted as T1 then the prime was processed and T2 identification was enhanced. Folk et al. proposed that the distractor box led to capture of central attention making the whole event salient and leading to involuntary selection of the letter presented within the distractor box. Following this logic, in Experiment 3 of the present study the distractor letter presented with the peripheral elements was replaced by a letter whose identity matched that of the target, and thus served as a prime. If peripheral elements captured central attention without decreasing the resolution of the focus of attention then the benefit of the prime was expected to be reflected through enhanced target identification as observed by Folk et al. (2008). There are two possible effects of presenting the prime within peripheral elements that group to form a face. On one hand, involuntary selection of the prime might be stronger when it is accompanied by a meaningful grouping than by a meaningless grouping. This would manifest as better target identification on meaningful than on meaningless trials. Alternatively, the identity of the prime might be amalgamated within the identity of the perceptual group (i.e., it becomes the “nose” of the Gestalt face; Eastwood et al., 2003) and, if so, the prime might be less effective on trials in which the peripheral elements formed a face than on meaningless trials. That is, T2 identification will benefit less from a prime that matches T2 when the peripheral elements form a face than when no such grouping is possible.

Two hypotheses were tested in this experiment.

6.1 Hypothesis 1

If peripheral elements make the whole event more salient, the prime will be processed and T2 identification will be enhanced at short temporal lags.

6.2 Hypothesis 2

If the identity of the perceptual group is processed then the benefit of the prime will be reduced when the peripheral elements form a face relative to when they do not.

6.3 Methods

6.3.1 Subjects. Twenty students participated in this experiment.

6.3.2 Stimulus and procedure. The procedure was same as described in the General Methods except that on experimental trials the distractor letter presented with the peripheral elements was replaced by a prime for all trial types in the 2 (meaning) x 2 (relevance) design. Please refer to Figure 8 for an example of the events on a trial in which the prime is surrounded by meaningless task-irrelevant peripheral elements.

6.4 Results

The mean accuracy with which T2 was identified on experimental trials was calculated and arcsine transformed. These transformed scores from each cell (involving 4 levels of lag, 2 levels of relevance, and 2 levels of meaning) were computed for each subject and submitted to a repeated-measures ANOVA. The baseline condition is presented for comparison only. For simplicity, only the main effects and interaction that pertain to the research questions addressed in Experiment 3 are discussed in this section. Please refer to Table 2 for other significant main effects and interactions. The main effect of meaning was significant, $F(1, 19) = 6.25$, $MSE = 71.49$, $p < .02$, $\eta_p^2 = .25$ indicating

Figure 8: Events on a meaningless irrelevant trial in Experiment 3

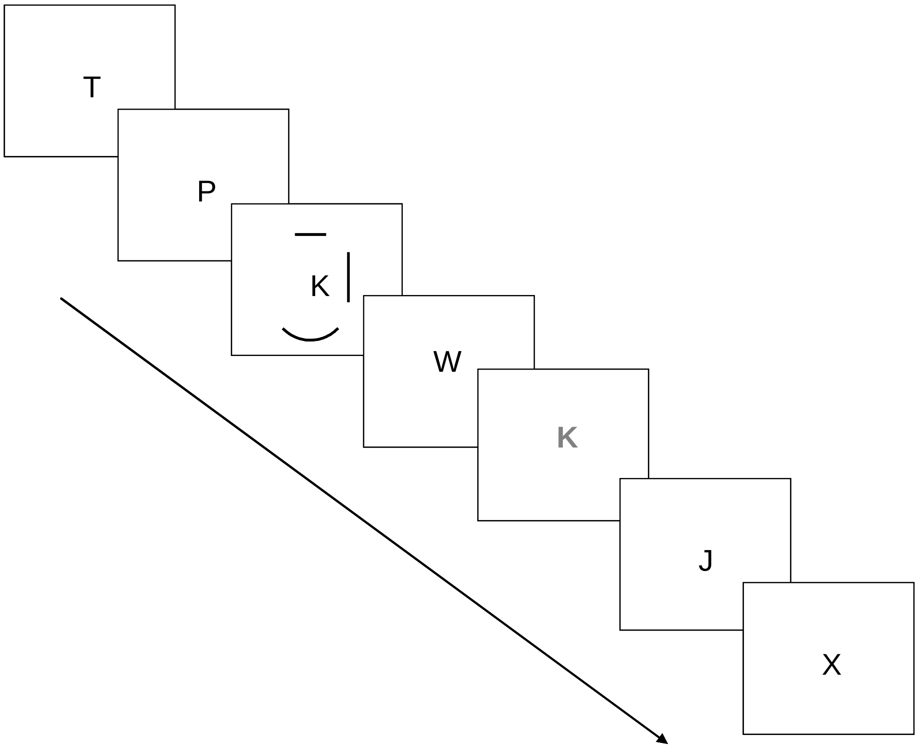
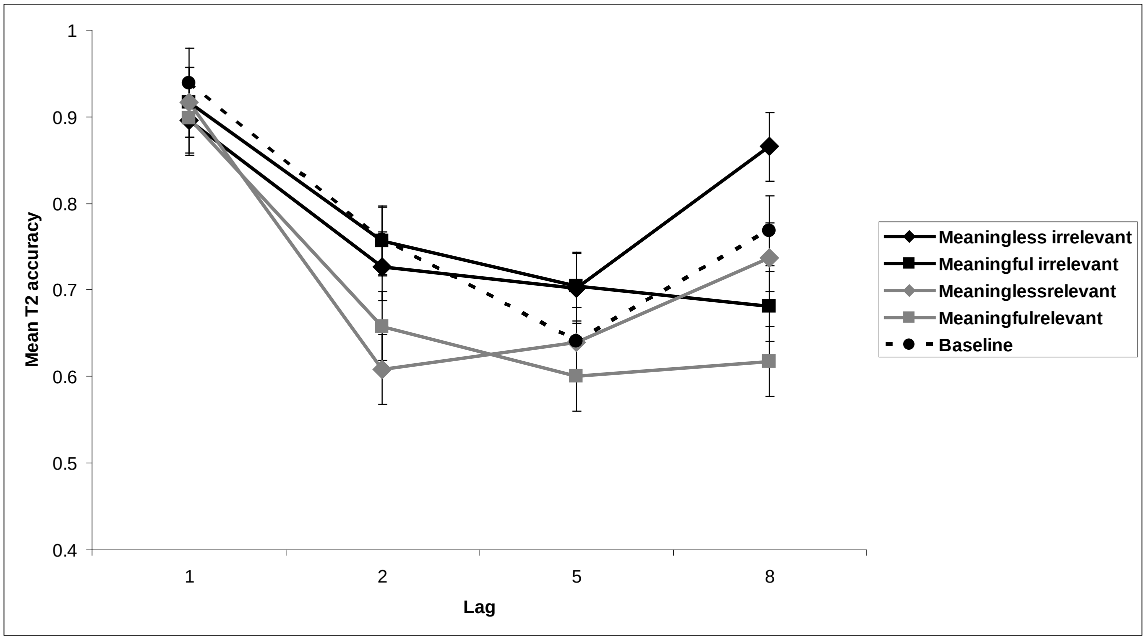


Table 2 shows the significant main effects and interactions of Experiment 3 not reported in the results section

Factors	df	*F*	MSE	*P*	η_p^2
Relevance	(1,19)	30.721	68.730	.000	.618
Lag	(3,57)	60.190	112.624	.000	.760
Relevance X lag	(3,57)	2.678	69.027	.056	.124
Relevance X meaning X lag	(3, 57)	2.765	52.427	.050	.127

greater impairment in T2 identification when the peripheral elements grouped meaningfully (*M* = .73) than when they did not (*M* = .76). The two-way interaction between relevance and meaning was not significant, $F < 1$. The two-way interaction between meaning and lag was significant, $F(3, 57) = 9.58$, $MSE = 71.06$, $p < .001$, η_p^2 =.34, indicating that T2 identification was impaired at longer lags to a greater extent when the peripheral elements formed a face than when they did not, which was similar to the effect observed in Experiment 2. The three way interaction between relevance, lag, and meaning was marginally significant, F (3, 57) = 2.77, $MSE = 52.43$, $p > .05$, η_p^2 = .13, indicating that task-relevant rather than task-irrelevant peripheral elements that did not form a face reduced T2 identification at short temporal lags more than when the peripheral elements formed a face, an effect that was reversed at longer lags. Please refer to Figure 9 for the accuracy with which T2 was identified in each condition. To interpret the marginal 3-way interaction, the effect of meaning on T2 identification was analyzed separately for task-irrelevant and relevant trials. For both trial types, the two-way interaction between meaning and lag was significant, $F(3, 57) = 11.1$, $MSE = 55.7$, $p < .01$, $\eta_p^2 = .37$ (irrelevant trials); $F(3, 57) = 3.09$, $MSE = 67.8$, $p < .03$, $\eta_p^2 = .14$ (relevant trials). Both analyses indicated that T2 accuracy was impaired to a greater extent at short temporal lags (lag 2) when the peripheral elements did not form a face than when they formed a face, but this interaction was reversed at the lag 8 position. Two additional analyses were carried out; the first one was carried out to examine whether the effect of meaning on attentional capture was transient or not. The second analysis was carried out to examine whether the prime presented with the peripheral elements was processed or not.

Figure 9: T2 accuracy in Experiment 3 as a function of relevance, lag and meaning.



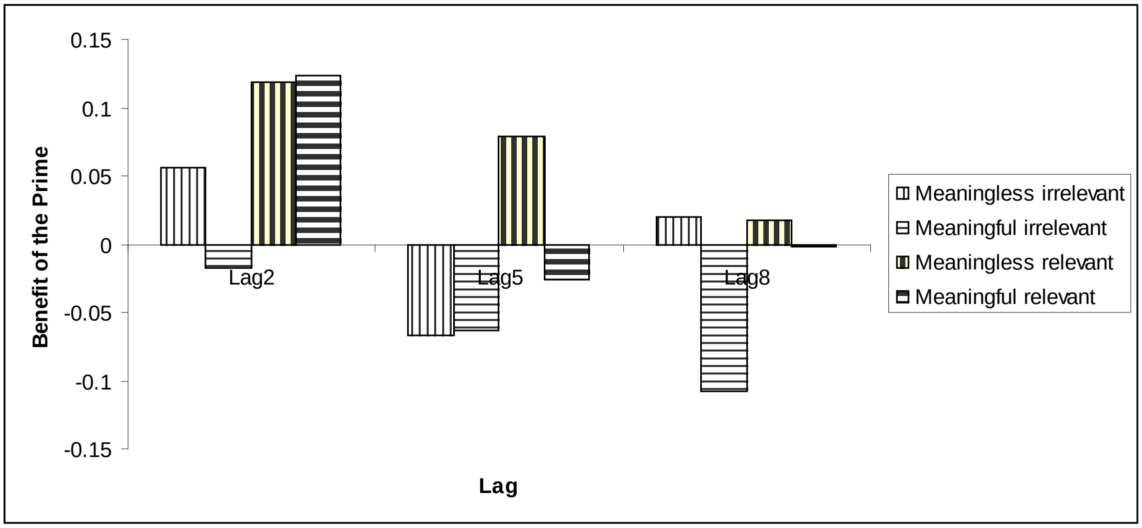
6.4.1 Comparison of T2 accuracy at short lags. If the effects of meaning are transient then it will be reflected mostly in the accuracy with which T2 is identified at short temporal lags. A repeated measures ANOVA was carried out to compare T2 accuracy at lag 1 and 2. Greater impairment in T2 identification was expected on the meaningful trials than on meaningless trials because the identity of the prime was expected to be amalgamated within that of the affective Gestalt face on meaningful trials. Neither the main effect of meaning nor the interaction of meaning with other factors were significant, all Fs < 1, all *p*s > .34, showing that attention capture was not influenced by whether or not the peripheral elements formed a face. The two-way interaction between relevance and lag was significant, $F(1, 19) = 7.14$, $MSE = 55.1$, $p < .02$, $\eta_p^2 = .27$, indicating that attention was captured to a greater extent at lag 2 when the peripheral elements were task-relevant than when they were task-irrelevant.

6.4.2 Comparison between Experiment 2 and 3. A comparison between prime absent (Experiment 2) and present (Experiment 3) was carried out to test whether the presence of peripheral elements forming a face influenced processing of the prime presented in the same frame. The prime matched the identity of the target letter but not the colour, and when the prime was present the target letter was present for twice the duration at Lag 1 than at other positions and thus was not comparable to the Lag 1 position of Experiment 2 so lag 1 data were excluded from this analysis. Presence of the prime was a between subjects variable in this analysis. The main effect of prime was not significant, $F < 1$, $p > .9$. The main effect of meaning was also not significant, $F < 2$, $p > .1$; but the two-way interaction between meaning and prime was significant, $F(1, 44) = 6.56$, $MSE = 71.51$, $p < .01$, $\eta_p^2 = .13$, showing that the benefit of the prime was reduced when the peripheral elements formed a face relative to when they did not. The two-way interaction between relevance and prime was significant, F (1, 44) =15.97, MSE = 61.08, p < .001, η_p^2 = .27, indicating that T2 identification was enhanced when the prime was presented with the task-relevant peripheral elements in Experiment 3 (M =.64) relative to when the prime was absent in Experiment 2 (M=.60), but no such effect was observed with task-irrelevant peripheral elements. The interaction between lag and prime was significant, F (2, 88) = 7.16, MSE = 72.12, p < .001, η_p^2 = .14, indicating that T2 identification was enhanced by the presence of the prime more at shorter lags than at longer lags. The four-way interaction between relevance, meaning, lag and prime was significant, F(3, 132) = 3.36, MSE = 53.59, p< .02, η_p^2 = .07, indicating that the benefit of the prime was reduced when task-irrelevant elements formed a face more than when the prime was presented with the task-relevant peripheral elements forming a face, particularly at the shortest lag. Please refer to Figure 10 for the benefit of the prime in the different conditions. To more fully interpret the 4-way interaction, the benefit of the prime was examined on the irrelevant and relevant trials separately. The two-way interaction between meaning and prime was significant on task-irrelevant trials, F(1, 44) = 5.00, MSE = 401.6, p< .03, η_p^2 = .10, indicating that the benefit of the prime was less when the peripheral elements grouped meaningfully than when they did not. This effect was not observed for task- relevant trials. Meaning did not interact with any other factors for either the irrelevant or the relevant trials.

6.5 Discussion.

Three interesting observations were made in Experiment 3. First, the results showed that meaning impaired T2 identification, however further investigation showed

Figure 10: Benefit of the prime as a function of relevance, lag and meaning.



that this was driven by relevance rather than meaning. Second, AB recovered less at long lags when the peripheral elements formed a face than when they did not. Third, as compared to Experiment 2, the benefit of the prime was not reduced when the peripheral elements were task relevant. Fourth, the benefit of the prime in Experiment 3 was reduced when the peripheral elements formed a face compared to Experiment 2 in which the prime was absent. The results of Experiment 3 confirmed the findings of Experiment 2, showing that task relevance and the lag at which T2 is presented influences the ability to report the identity of T2, but meaning does not directly.

Comparison of the accuracy with which T2 was identified in the presence and absence of the prime supports hypothesis 1 and confirms the claim made by Folk et al. (2008) that, as proposed in hypothesis 1, attention was captured by the presence of task-relevant peripheral elements without decreasing the resolution of the focus of attention. The presence of task-relevant peripheral elements made the whole event more salient, leading to involuntary selection of the prime presented in the same frame as the peripheral elements, which in turn enhanced the ability to report T2. However, the benefit of the prime was reduced when the peripheral elements formed a face, which supports hypothesis 2. A higher order interaction showed that in this case the effect was probably influenced by relevance, such that the benefit of the prime was reduced to a greater extent when the task-irrelevant peripheral elements grouped meaningfully. This indicates that the identity of the prime was probably difficult to extract from that of the face on the task-irrelevant trials because the peripheral elements and the prime were both black in colour. Consistent with the findings reported in the spatial attention literature (Eastwood et al., 2003; Eastwood et al. 2008), the findings of this comparison also suggest that the peripheral elements and accompanying distractor letter were grouped together as a whole and attention was not allocated to the individual elements within the perceptual group. Consequently, the identity of the prime was not processed and the benefit of the prime was not reflected in the accuracy with which T2 was identified. This indicates that amalgamation of the prime within the perceptual grouping reduced processing of the prime and thus the benefit of the prime in identifying T2.

Although the meaningfulness of the peripheral elements appears to have influenced processing of the distractor accompanying them, however there is little evidence that central attention was captured in a way that led to impaired T2 identification. If meaning (faces) captured central attention then T2 accuracy was expected to be lower when presented within 500 ms of the presentation of the peripheral distractors at lags 1 and 2. No effect of faces was observed when T2 accuracy was analysed at these lags. Rather impaired T2 identification on meaningful trials was observed after 500 ms (at lag 8). In this case the effect of the face was reflected in the delayed recovery from AB at long lags. Further, the four way interaction showed that the benefit of the prime was reduced when the colour of the prime and the peripheral elements matched on task –irrelevant trials. This might indicate that the formation of the perceptual group was facilitated by bottom up salience (colour match) and thus that the grouping was not formed automatically. Two reasons are proposed to account for this observation. First, it is possible that faces do not capture central attention in the same way as they have been observed to capture spatial attention. Second, the effect of faces is transient and their effect is only observed on information presented with the meaningful grouping (i.e., immediately). Because T2 was not presented with the peripheral elements, faces did not impair T2 identification. Alternatively, it is possible that, because subjects were not required to report any information presented with the peripheral elements, perhaps they were simply very successful in filtering them from awareness. Important to note here is the effect of the prime was a between subjects variable so it is possible that subject characteristics might have influenced the effect of the prime as well. An AB was also observed on the baseline trials on which the peripheral elements were absent. This may be explained by repetition blindness, a phenomenon in which repetition of an item in the stream leads to poor ability to report its identity (Kanwisher, 1987). This might mean that the blink in this experiment was due to repetition blindness rather than to central attention capture by peripheral elements on the task-irrelevant trials. Verbal reports taken from subjects again indicate that only 35% of subjects were aware of the presence of the face although faces were presented on 208 trials in the experiment.

In summary, task relevant peripheral elements captured central attention such that the whole event was made more salient, leading to the involuntary processing of the prime presented with it. Consequently, subsequent target identification was enhanced. However, the identity of the prime seemed to be impaired when the peripheral elements formed a face especially on the task-irrelevant trials, indicating that the effect of meaning appears to be limited to information present on the same frame, without impairing subsequent target identification as would be expected if central attention was captured by the meaningful group.

7. Experiment 4: Is Target Identification Impaired When it is Embedded within a Face?

In studies examining how meaning influences the allocation of spatial attention, the target was displayed with meaningful distractors (Eastwood et al. 2003; Forster & Lavie, 2008). In those experiments, the ability to report a target accompanied by meaningful distractors was impaired, suggesting the distractors drew spatial attention from processing the target, an effect replicated in Experiment 1 of the present study. In Experiment 4, I tested whether central attention can be captured by meaning in the same way as spatial attention, leading to impaired ability to detect a target presented with peripheral elements forming a face. In contrast to Experiments 2 and 3, subjects in this experiment reported two targets (T1 and T2) as in the standard attentional blink paradigm; T1 was thus the item surrounded by peripheral elements, and like T2, was coloured red to distinguish it from non-target letters. By employing this paradigm it was possible to examine the extent to which attention captured by peripheral elements impaired identification of a target presented in the same frame (i.e., whether the presence of peripheral elements forming a face impaired the ability to report T1 to a greater extent than when no face was formed). Additionally, by monitoring the accuracy with which the second target was identified it was possible to examine whether more resources were required to identify the first target when the first target was embedded in a face formed by peripheral elements. That is, greater impairment in T2 identification suggests that more resources were allocated to the processing of T1, so these resources were unavailable for T2 identification. Two hypotheses were tested in this experiment.

7.1 Hypothesis 1

If the identity of the peripheral elements forming a face is processed then T1 identification will be impaired.

7.2 Hypothesis 2

If processing peripheral elements forming a face increases the difficulty of processing of T1 and reduces the availability of central attention for processing T2, then T2 accuracy will be lower when the elements form a face than when they do not.

7.3 Methods

7.3.1 Subjects. Eleven students participated in this experiment.

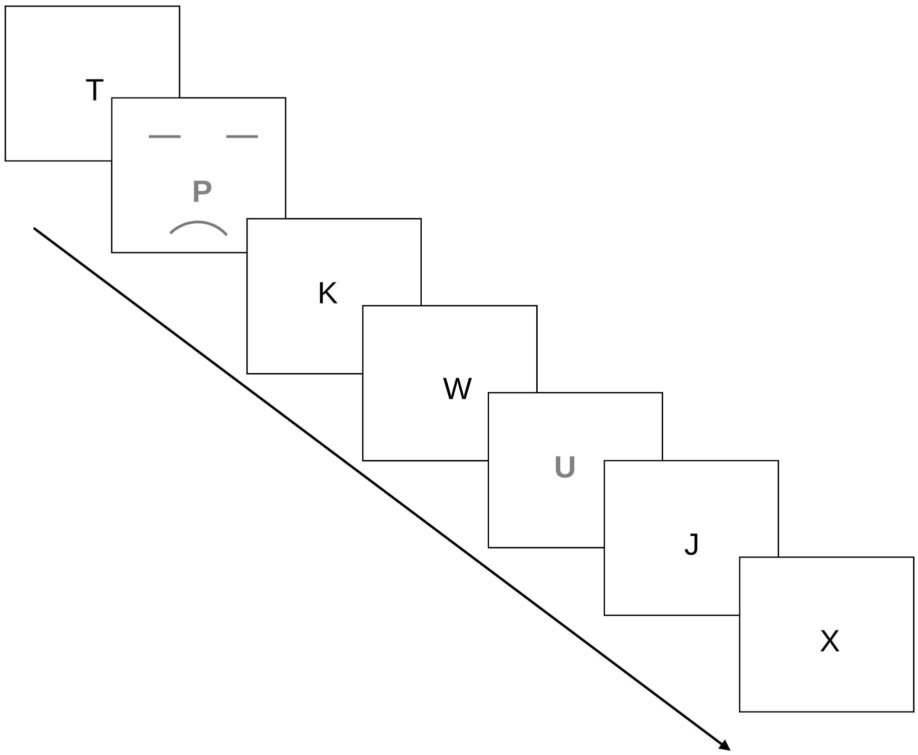
7.3.2 Stimuli and procedure. The general experimental paradigm was the same as that described in the General Methods section except that subjects were required to report two red target letters, T1 and T2. The manipulation of relevance was achieved by presenting the peripheral elements in the colour of the target letter (i.e., red; task-relevant) or in the colour of the distractor letters in the stream (i.e., black; task-irrelevant). T1 and T2 were always presented in red. Please refer to Figure 11 for and example of the events on a relevant meaningful trial.

7.4 Results

The mean accuracy with which T1 and T2 were identified on experimental trials was calculated and arcsine transformed. Transformed scores for T1 and T2 were analyzed separately in two repeated measures ANOVAs.

7.4.1 Analysis of T1 identification. In the first analysis, T1 accuracy served as the dependent variable and meaning (face/non-face), relevance (black/red), and lag (1, 2, 5 and 8) served as independent variables. The two-way interaction between meaning and lag was significant, $F(3, 30) = 5.59$, $MSE = 59.7$, $p < .004$, $\eta_p^2 = .36$, indicating that peripheral elements forming a face impaired T1 identification when T2 was presented at Lag 1, an effect that reverses at lag 8. No other main effects or interactions were

Figure 11: Events on *meaningful relevant* trial Experiment 4



significant.

7.4.2 Analysis of T2 identification. In the second analysis of T2 accuracy, only data from trials on which T1 was identified correctly in the experimental trials were analyzed; 84% of experimental trials were included in the analysis. Of key interest in this experiment was whether more resources were allocated to the processing of T1 when it was surrounded by peripheral elements forming a face, thereby impairing T2 identification. Therefore, only the effects relevant for addressing this question will be discussed in this section; please refer to Table 3 for other main effects and interactions. The main effect of meaning was not significant, $F < 1$, indicating that T2 identification was not influenced by whether or not peripheral elements surrounding T1 formed a face. Meaning did not interact significantly with any other factor, all Fs < 2, all ps>. 4. Please refer to Figure 12 for a representation of the accuracy with which T2 was identified in each condition.

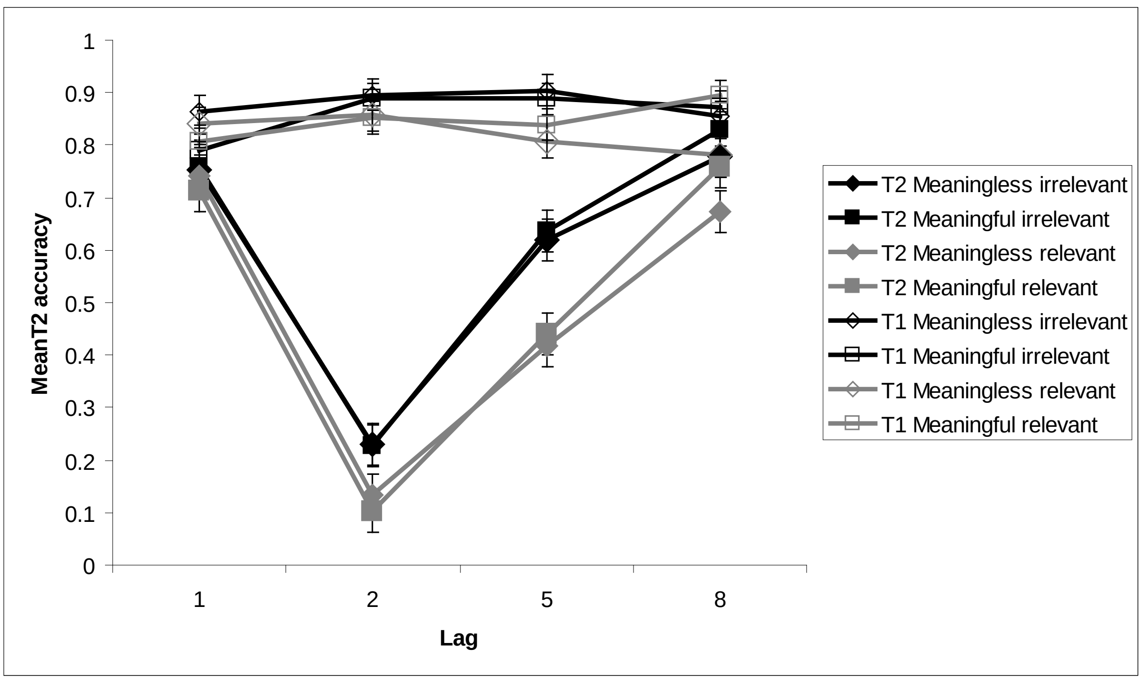
7.5 Discussion

Three interesting observations were made in this experiment. First, overall T1 identification was not influenced by the presence of task-relevant peripheral elements present in the same frame. Second, there was some evidence that T1 identification was impaired by whether or not the peripheral elements formed a face when T2 was presented immediately after T1. Third, T2 identification was not influenced by whether or not the peripheral elements formed a face. The results of Experiment 4 again confirm the finding of Experiment 2 and 3 that T2 identification was impaired by relevance and lag but not by whether or not the peripheral elements formed a face. There is some evidence that T1 identification was impaired when it was embedded within the face and T2 was presented

Table 3: Main effects and interactions not reported in the Results section.

Factors	df	F	MSE	P	η^2
Relevance	(1,10)	83.290	40.760	.000	.893
Lag	(3,30)	40.509	379.989	.000	.802
Relevance X meaning	(1, 10)	.871	62.013	.373	.080
Relevance X Lag	(3,30)	1.414	94.475	.258	.124
Meaning X Lag	(3,30)	2.614	53.348	.069	.204
Relevance X meaning X Lag	(3,30)	.965	39.169	.422	.088

Figure 12: T1 and T2 accuracy in Experiment 4 as a function of relevance, lag and meaning.



immediately after. This effect was similar to the reduced benefit of the prime observed in Experiment 3 and consistent with the literature (Eastwood et al., 2003). This could be because T1 identity was amalgamated within the identity of the face as a whole and was difficult to extract. This effect is also observed in Experiment 3 in which the effect of the prime is reduced when the peripheral elements formed a face. Further, Chun and Potter (1995) observed such an effect, finding that the accuracy with which T1 can be reported is influenced by the extent to which T1 can be distinguished locally from the item that follows immediately after.

A surprising finding was that at lag 8 peripheral elements not forming a face impaired T1 identification. Given the various theories and explanations offered in the AB literature there is no clear explanation for this effect.

Important to the present discussion is the finding that the results of three experiments show that central attention is captured by the peripheral elements in a way that impairs T2 identification. However this central attention capture is not further exacerbated by whether or not the peripheral elements form a face. This may indicate that central attention is not modulated by meaning in the same way as spatial attention.

Alternatively, in a demanding RSVP task, the focus of attention is maintained narrowly over the known target location to maximize accurate target identification (Jefferies & Di Lollo, 2009) so elements presented in the periphery are not likely to be attended. It is possible that the input filter (Di Lollo et al., 2005) adopted allows processing of targets only and prevents processing of any other elements not matching the target specification. Further, verbal reports reveal that only 9% of the subjects reported seeing the face in this experiment, suggesting they were quite successful in filtering the distractors from awareness. It is important to note that subjects were informed that two straight lines and a curve would be presented with one of the targets and that they should ignore these stimuli to ensure they do not miss the target. Therefore, it is possible that the instructions biased subjects to perceive the peripheral elements individually rather than as a perceptual group or as a Gestalt face. Alternatively, it is possible that the stimulus pattern was such that a sad face or and happy face could not be perceived in the elements shown, especially with a brief exposure duration. These alternatives were investigated in Experiment 4a.

8 Experiment 4a. Can a Gestalt Face be Perceived from the Stimulus Configuration?

This experiment was carried out to rule out two possibilities: (1) that the reason the faces did not influence target identification is because a face could not be perceived from the way the two straight lines and the curve were arranged in the experiment, and (2) whether the instructions biased subjects to perceive the two straight lines and curve as individual elements, and, as such, subjects did not process the peripheral elements as a group that formed a face.

8.1 Methods

8.1.1 Subjects. Eleven subjects participated in this experiment

8.1.2 Procedure and design: The experimental design of Experiment 4a was identical to that of Experiment 4 except that two blocks were added at the beginning of the experiment. First, subjects were required to correctly report whether the perceptual group resembled a face or not. Four arrangements of the two straight lines and a curve were presented. Two of the arrangements were randomly chosen from the set of 20 non-face images shown in Figure 2 along with the happy face and the sad face. All subjects identified the groups that did not form a face, the happy face, and the sad face correctly. After the *free report* block, subjects completed 4 experimental trials in which the peripheral elements were present but instead of reporting the identity of the red letter subjects reported the identity of the perceptual group formed by the peripheral elements (*identification block*). The trials on this block were identical to the experimental trials of Experiment 4, except subjects were not required to report the identity of the two red letters and the peripheral elements were black. Subjects pressed 1 on the computer keyboard when the peripheral elements did not form a face, 2 when the peripheral elements formed a happy face, and 3 when the peripheral elements formed a sad face. The experimenter monitored this session to ensure that subjects attained 100% accuracy in this block. All subjects were able to acquire 100% accuracy in one block. After subjects completed the *identification block* they were informed that the perceptual groups they saw in the *identification block* would appear randomly on the subsequent experimental trials. Subjects were again explicitly instructed to ignore the perceptual groups and to report the identity of two red letters in the RSVP stream. The subsequent experimental trials were identical to the experimental trials presented in Experiment 4.

8.2 Results

8.2.1 Analysis of T1 identification. Mean T1 accuracy scores from each cell were arcsine transformed prior to analysis. T1 accuracy served as the dependent variable and meaning (face/non-face), relevance (black/red), and lag (1, 2, 5 and 8) served as independent variables. The main effect of meaning was not significant, $F < 1$; no difference was observed in T1 accuracy in the presence of peripheral elements forming a face (.86) or not (.87). The two-way interaction between meaning and relevance was significant, $F(1, 10) = 21.5$, $MSE = 23.0$, $p < .001$, $\eta_p^2 = .68$, indicating that task relevant peripheral elements that do not form a face impaired T1 identification to a greater extent than when they formed a face, while this effect is reversed on task-irrelevant trials. The two-way interaction between meaning and lag was significant, $F(3, 30) = 4.11$, $MSE = 47.38$, $p < .02$, $\eta_p^2 = .29$, indicating that meaningful peripheral elements forming a face impaired T1 identification when T2 was presented in close temporal proximity to T1 and again this interaction is reversed at lag 8 as was observed in Experiment 4. No other main effects or interactions were significant. Please refer to Figure 14, which displays the mean accuracy with which T1 was identified in each condition.

8.2.2 Analysis of T2 identification. This experiment was carried out to examine whether peripheral elements forming a face impaired T2 identification when subjects were aware that a face was presented on the experimental trials, therefore only effects addressing this question will be discussed here. The main effect of meaning was significant, F (1, 10) =7.09, $MSE = 41.7$, $p < .02$, $\eta_p^2 = .42$, however the effect was in the opposite direction predicted, indicating that peripheral elements not forming a face (M=.52) impaired T2 identification to a greater extent than when they formed a face (M=.55). The two-way interaction between meaning and lag was significant, $F(3, 30)$ =3.54, $MSE = 35.1$, $p < .03$, $\eta_p^2 = .26$, indicating that peripheral elements not forming a face impaired T2 identification at long temporal lags more than peripheral elements forming a face. A t-test comparing performance at lag 2 across meaningful and meaningless trials showed that meaning did not influence T2 accuracy at the shortest lag, $t(1,10)= 1.18$, $p > .26$. Please refer to Table 4 for other main effects and interactions and to Figure 13 for the mean accuracy with which T2 is identified in each condition.

8.2.3 Comparison between Experiment 4 and 4a. This comparison was carried out to examine whether meaning influenced T1 and T2 identification after subjects were made aware of the presence of the emotional faces in the RSVP stream. Awareness was a between subjects variable in this analysis. The main effect of awareness was not significant, $F < 1$, indicating that there was no difference in T1 identification between Experiment 4 (M=.84) and Experiment 4a (M=.87) in which subjects were made aware of the identity of the peripheral elements. Therefore, other analyses were not carried out. The main effect of awareness was significant when T2 accuracy between the two experiments was compared, $F\ (1, 20) = 7.61$, $MSE = 8635$, $p < .01$, $\eta_p^2 = .28$, however, the effect was in the opposite of the direction expected. That is, T2 identification was better when subjects were informed that the faces were being presented on some experimental trials in Experiment 4a (M =.59) than when they were not informed about the faces in Experiment 4 (M =.49). The two way interaction between meaning and lag was significant when the data from Experiment 4 and 4a were pooled together, $F(3, 60) = 5.73$, $MSE = 44.3$, $p < .002$, $\eta_p^2 = .22$, indicating that peripheral elements forming a face impaired T2 identification at lag 2 to a greater extent than peripheral elements not forming a face; however, again this effect was reversed at longer lags. A t-test carried out to examine the effect of meaning at lag 2 showed that meaning did not influence T2 identification at lag 2, $t < .09$, $p > .77$, suggesting the larger (reversed) effect of meaning at lag 8 is responsible for the observed interaction with lag.

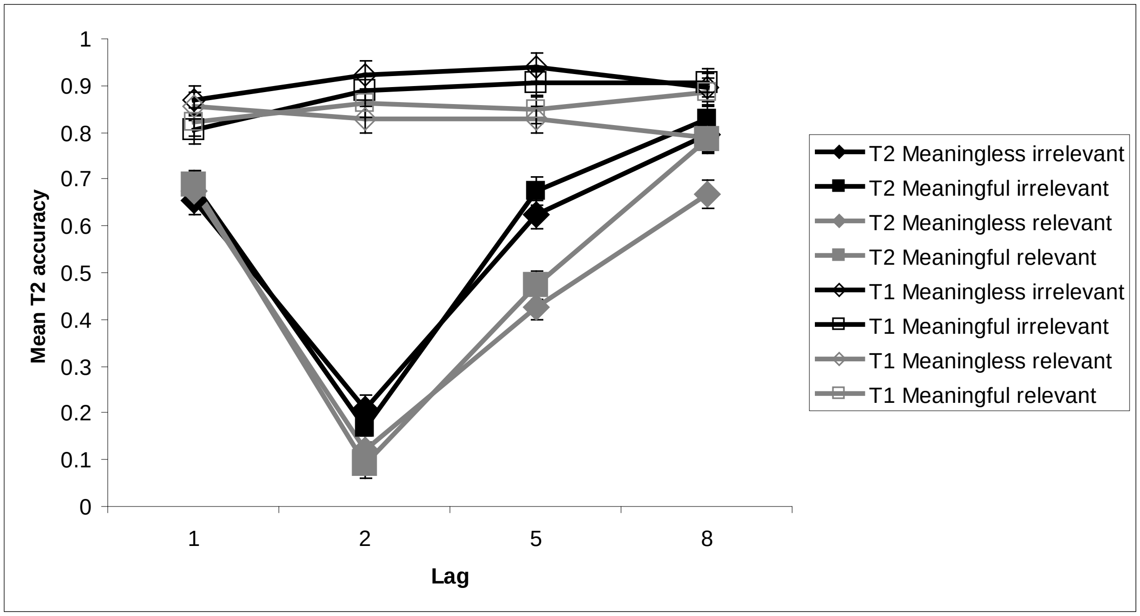
8.3 Discussion

The results of this experiment ruled out the possibility that the Gestalt images

Table 4: The main effects and interaction of Experiment 4a not reported in the result section.

Factors	df	*F*	MSE	*P*	η^2
Relevance	(1,10)	53.339	273.021	.000	.842
Lag	(3,30)	33.008	101.346	.000	.767
Relevance X meaning	(1,10)	.366	50.657	.558	.035
Relevance X lag	(3, 30)	25.414	152.468	.000	.718
Relevance X meaning X lag	(3, 30)	1.485	61.126	.239	.129

Figure 13: T1 and T2 accuracy in Experiment 4a as a function of relevance, lag and meaning.



could not be perceived as faces when shown on the experimental trials. All subjects were able to report the identity of the images shown in the *free report block.* Subjects were also able to report the identity of the images with 100% accuracy when RSVP sequences were presented in the experimental block and the task was to report the identity of the images rather than the two red target letters. However, when subjects were required to report the identity of the two target letters, meaning did not influence T2 accuracy. There is some evidence that T1 accuracy was impaired when it was embedded within the face; however, as observed in Experiment 4, the interaction reversed at lag 8. This effect is proposed to result from the decreased discriminability of T1 when T1 was embedded within the peripheral elements forming a face and interference from the immediate presentation of T2 at lag 1 (as reported by Chun & Potter, 1995). Verbal reports collected after Experiment 4a was completed showed that 27% of subjects were aware of the presence of the faces on the experimental trials. Although more subjects reported seeing the face after they were informed about the presence of the face in Experiment 4a this was comparable to the number of subjects who reported seeing the face in Experiment 2 and 3 in which subjects were informed about the peripheral elements only. That is, informing subjects about the presence of the faces on the experimental trials did not increase their ability to see them during the letter identification task. This shows that when the task requires subjects to report the identity of the two red letters, the focus of attention was adjusted and maintained narrowly over the target location, preventing awareness of faces that are seen easily when attention is less narrowly focused. When the area over which spatial attention spreads was controlled, the peripheral elements were not within the focus of attention and the identity of the face was not processed. Consequently, faces did not capture attention in a way that was detrimental to T2 identification. This indicates that the identity of the perceptual group or the Gestalt face can be processed when the peripheral elements are within the focus of attention.

In summary, the results from four studies indicate that peripheral elements can capture central attention impairing T2 identification however meaning does not further exacerbate this central attention capture. The effect of meaning that was observed in the four experiments seemed to be transient and was reflected only on the information presented on the same frame as the peripheral elements. Further, this impairment could be related to the reduced discriminability of the stimulus presented when the stimulus (prime in Experiment 3 and T1 in Experiment 4 and 4a) was amalgamated within the identity of the peripheral elements forming a face. It is important to note that the same Gestalt faces captured spatial attention, impairing target identification in Experiment 1. The results of Experiment 1 and Experiment 4a suggests that if the Gestalt faces are brought within the focus of attention then the effect of the face on target identification might be observed very briefly. In Experiment 5 an attempt was made to broaden the focus of attention.

9 Experiment 5. Can the Focus of Attention be Modulated by Varying the Size of the Letters in the Stream?

The area over which attention is spread spatially has been shown to be modulated by manipulating target location (Jefferies & Di Lollo, 2009) and by presenting targets in the same object or within different objects (Conci & Muller, 2009) in the RSVP paradigm. In a standard RSVP experiment (Chun & Potter, 1995; Nieuwenstein et al., 2005; Raymond et al., 1992) the size of the items and the location of the target are held constant and the time between the onset of the two targets is manipulated to examine the way in which the allocation of attention is influenced by time constraints (Dux & Mario, 2009). The results of Experiment 4a show that the identity of the perceptual group (face) can be recognized easily and almost immediately when it is the task focus, suggesting that spatial attention may be focused too narrowly to allow subjects to see the faces as faces in these experiments. In Experiment 5, the size of the letters was varied randomly to encourage subjects to maintain a wider focus of attention on each trial; because the target might be a small letter or a large letter, subjects ought to maintain a relatively broad distribution of attention in order to ensure that target letters of any size will be within the focus of attention when they are presented. If subjects maintain a wider focus of attention then the peripheral elements might be included in the focus of attention, especially when the letter accompanying the perceptual group is small and the total area subtended by the letter and the group is similar to the total area subtended by a large letter. If the peripheral elements are now able to be perceived as a face, then perhaps central attention will be captured by the identity of the perceptual group (face) to a greater extent than by random arrangements of lines. One hypothesis was tested in this experiment.

9.1 Hypothesis 1

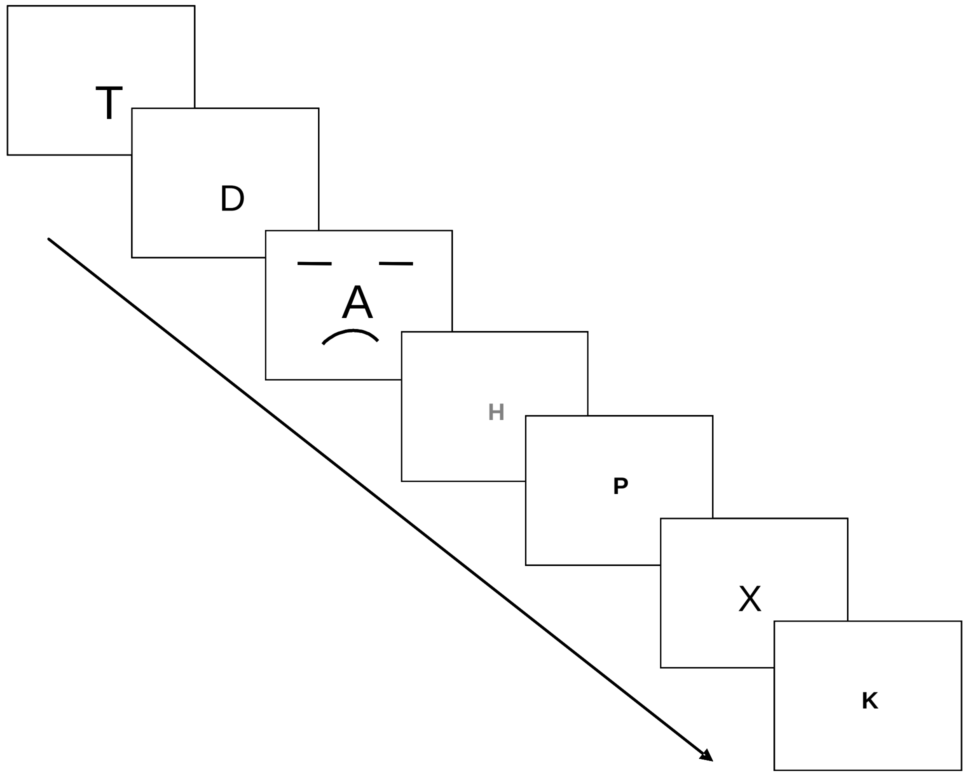
If the varying size of the items in the RSVP sequence enlarges the focus of attention then the identity of the perceptual group will be processed and T2 identification will be impaired more at shorter lags for meaningful groups than for meaningless groups.

9.2 Methods

9.2.1 Subjects. Fourteen students participated in this experiment.

9.2.2. Procedure and design: Experiment 5 was identical to that described in the General Methods section except that the size of each letter in the sequence was varied

Figure 14: Events on a trial in Experiment 5



randomly, except the letter immediately following the target, which was always the same size as the target in order to ensure the target was masked. The letters in the RSVP stream were presented in three different sizes: big, a font size of 56; medium, a font size 36; and small, a font size of 26. The size of the letters in all the other experiments reported in this dissertation was 36. Please refer to Figure 14 for the events on a meaningful trial on which the size of the items presented in the RSVP sequence is varied randomly.

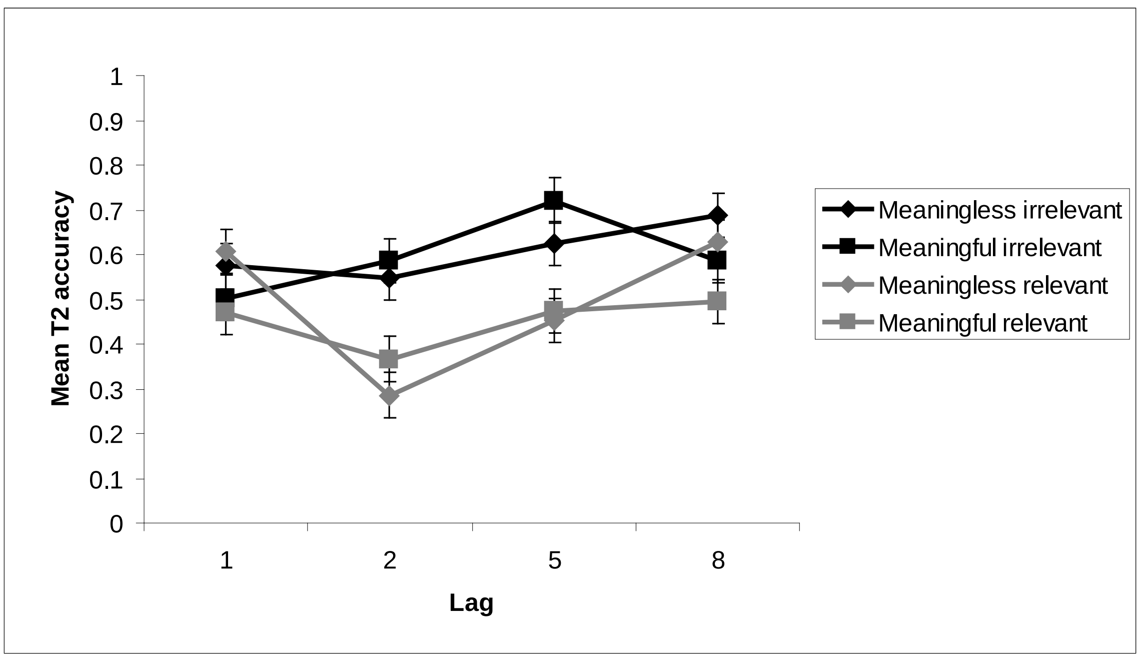
9.3 Results

T2 accuracy in the experimental trials was the dependent variable. Relevance, meaning and lag were the independent variables. The mean T2 accuracy from each cell for each subject was arcsine transformed and submitted to a repeated measures ANOVA. It is important to note that the size of the letter was manipulated to increase the area over which attention was spread rather than as an independent variable. As in previous studies, only the effects relevant to the research question will be discussed; please refer to Table 5 for the results of the full analysis. The main effect of meaning was not significant, $F(1, 13) = 1.91$, $MSE = 84.19$, $p > .19$, $\eta_p^2 = .13$, indicating that there was no difference between T2 identification when the peripheral elements formed a face ($M = .53$) and when they did not ($M = .55$). The two-way interaction between meaning and lag was significant, $F(3, 39) =7.42$, $MSE = 103.13$, $p > .001$, $\eta_p^2 = .36$, however the interaction was in the direction opposite to what was predicted; that is, peripheral elements that do not form a face impaired T2 identification at shorter temporal lags to a greater extent than peripheral elements forming a face. However, the recovery from the blink is slow when the peripheral elements form a face. Please refer to Figure 15 for the means of T2 identification in the different conditions

Table 5: The main effects and interactions of Experiment 5 not reported in the result section

Factors	df	*F*	MSE	*P*	η^2
Relevance	(1,13)	27.381	143.936	.000	.678
Lag	(3,39)	13.217	69.486	.000	.504
Relevance X meaning	(1, 13)	2.518	38.694	.137	.162
Relevance X Lag	(3,39)	7.424	103.133	.000	.364
Meaning X Lag	(3,39)	10.378	55.186	.000	.444
Relevance X meaning X Lag	(3,39)	.722	46.387	.545	.053

Figure 15: Mean T2 accuracy in Experiment 5 as a function of relevance, lag and meaning.



9.4 Discussion

The results of this experiment show that faces did not impair T2 identification as observed in the visual search task in Experiment 1 or other spatial attention studies. The size of the letters presented in Experiment 5 was varied randomly. Subjects were unaware of the target size for each trial and therefore they would benefit from maintaining a wider focus of attention to ensure targets of all sizes would be brought under the focus of attention. If the focus of attention was enlarged then the peripheral elements would also be brought under the focus of attention and the identity of the perceptual groups forming a face would be perceived[6]. Consequently, the presence of the face was expected to interfere with target identification. This manipulation did not influence performance in the way predicted. The main effect of meaning was not significant and the interaction of meaning and lag was in the opposite direction than what was predicted; that is, non-face peripheral elements impaired T2 identification more at short temporal lags than when the peripheral elements formed a face. This effect however was reversed at longer lags in which T2 identification was impaired to a greater extent when the peripheral elements formed a face than when they did not. This experiment again confirms the finding of Experiments 2 – 4a that meaning (faces) did not impair T2 identification at short lags. Verbal reports collected after the completion of the experiment showed that 29% of subjects reported seeing the face on some experimental trials. Another attempt was made in Experiment 6 to facilitate the processing of the Gestalt face that is presented on some of the experimental trials.

[6] The results showed that T2 accuracy was impaired to a greater extent when the distractor letter presented with the peripheral elements was large (.50) than when it was small (.56), indicating that the size of the distractor letter might have led to an increase in the area under the focus of attention allowing more interference from the peripheral elements.

10 Experiment 6 Can the Presence of Task Relevant Features in the Periphery Broaden the Focus of Attention?

In Experiments 2-4a the presence of task-relevant features led to the capture of central attention in a way that was detrimental for T2 identification. Lag 1 sparing was also observed in Experiments 4 and 4a such that T2 presented in close temporal proximity to the task-relevant peripheral elements and T1 led to better T2 identification than when T2 was presented at other lag positions. This is proposed to be due to the sluggish closing of an “attention gate” that monitors the selection of items for further processing (Raymond et al., 1992). Following this logic, in this experiment a red hexagon was presented in the frame immediately preceding the peripheral elements. If attention is captured by the presence of the red hexagon and the focus of attention is broadened, perhaps that will allow the perceptual group formed by the peripheral elements in the subsequent frame to be brought within the focus of attention, allowing the perceptual group that is presented at lag 1 to be processed as a face. Consequently, if subjects are now processing the peripheral elements as a face and faces capture attention more effectively than random lines, then T2 identification will be impaired when T2 is presented at a short temporal lag. One hypothesis was tested in this experiment

10.1 Hypothesis 1

If the focus of attention is broadened by the presence of the red hexagon then the identity of the face will be processed and T2 identification will be impaired.

10.2 Methods

10.2.1 Subjects. Twenty students participated in this experiment.

10.2.2 Stimulus and apparatus. The stimuli were identical to the stimuli in

Experiment 2 except that on some trials an outline hexagon, drawn with red broken lines, appeared. This hexagon was presented in the frame immediately preceding the peripheral elements on half of the experimental trials. The peripheral elements were always presented in black. The size of the hexagon was such that had it appeared concurrently with the peripheral elements, it would completely encompass them, perhaps broadening the focus of attention sufficiently to ensure that the peripheral elements were within the focus of attention and, in turn, that they could perhaps now be perceived as a face.

10.2.3 Procedure and design. The experimental design of Experiment 6 was identical to the procedure mention in the General Methods section except two changes were introduced in the design. First, the peripheral elements always matched the colour of the distractor letter and were black in colour throughout the experiment. Second, in the second part of the experimental block a red hexagon was presented before the presentation of the peripheral elements. The hexagon-absent trials served as a baseline. The target letter was always presented after the peripheral elements. The design of this study was thus 2 (hexagon present/absent) x 4 (lag) x 2 (meaning). Please refer to Figure 16 for the events on a trial on which the hexagon was present.

10.3 Results

The mean T2 accuracy was calculated and arcsine transformed. Transformed scores for T2 were submitted to a repeated measures ANOVA with T2 identification as the dependent variable and hexagon (present/absent), meaning (face/non-face) and lag (1, 2, 5 and 8) as the independent variables. The hexagon was introduced to broaden the focus of attention perhaps allowing the identity of the face to be processed, therefore only the effects addressing the influence of meaning will be discussed here; please refer to

Figure 16: Events on a trial on which a red hexagon present meaningful trial

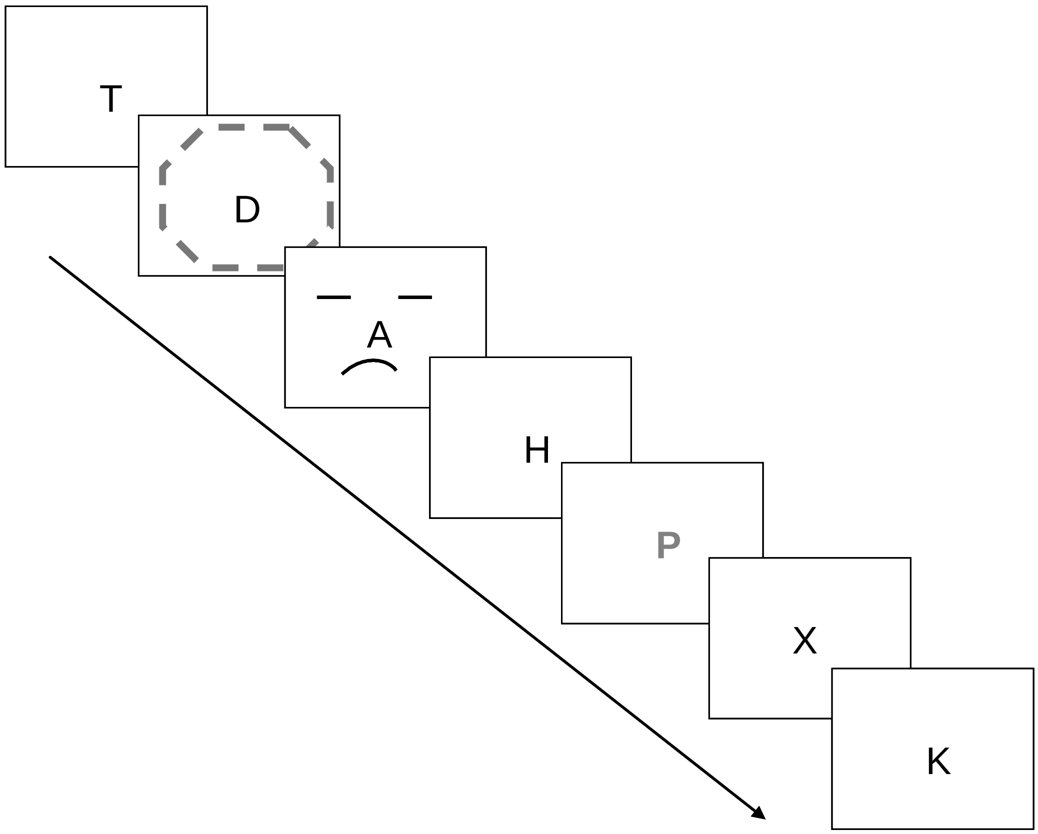


Table 6 for other main effects and interactions. The main effect of the presence of the hexagon was significant, $F(1, 19) = 6.3$, $MSE = 91.09$, $p < .02$, $\eta_p^2 = .25$, indicating T2 identification was less accurate when the hexagon was present ($M = .62$) than when it was absent ($M = .65$). The main effect of meaning was not significant, $F < 1$, indicating that T2 identification was not influenced by whether or not the peripheral elements formed a face (face $M = .64$; non-face $M = .63$). The interaction between the presence of the hexagon and meaning was significant, $F(1, 19) = 10.03$, $MSE = 51.61$, $p < .01$, $\eta_p^2 = .35$, indicating that in the presence of hexagon, the peripheral elements not forming a face impaired T2 identification to a greater extent than when they did form a face. The three-way interaction between presence of hexagon, meaning, and lag was also significant, $F(3, 57) = 5.74$, $MSE = 58.4$, $p < .001$, $\eta_p^2 = .23$, indicating that in the presence of the hexagon, non-face peripheral elements impaired T2 identification at short temporal lags to a greater extent than when they formed a face. Please refer to Figure 17 for the accuracy with which T2 was identified in each condition.

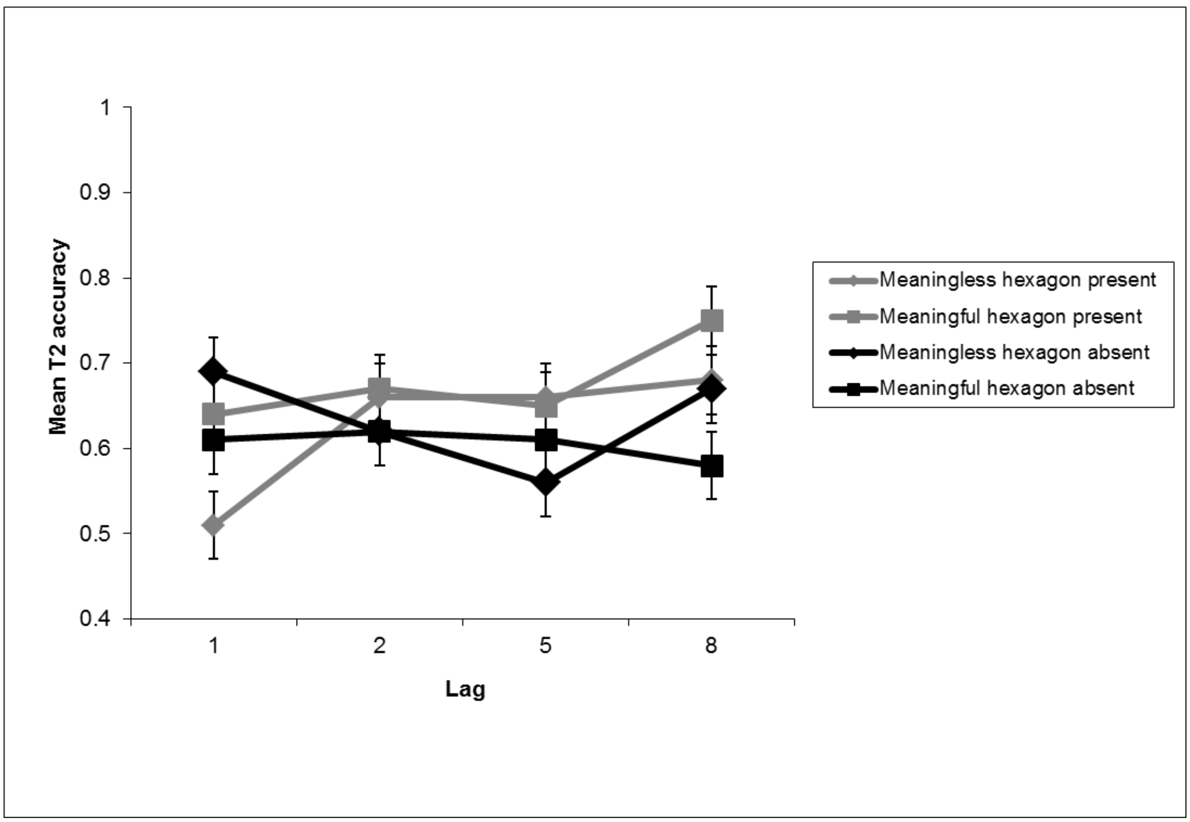
10.4 Discussion

The hexagon was introduced to broaden the focus of attention. A significant main effect of the presence of the hexagon shows that the red hexagon captured attention. However, the results of this experiment provide no evidence to indicate that the identity of the face was processed in a way that was detrimental to accurate T2 identification. The main effect of meaning was not significant and the significant interaction between the presence of the hexagon and meaning showed instead that when the hexagon was present peripheral elements that did not form a face impaired T2 identification to a greater extent than those that formed a face. The significant three-way interaction between the presence

Table 6: The main effects and interactions of Experiment 6 not reported in the result section.

Factors	df	*F*	MSE	*P*	η^2
Lag	(3, 57)	2.621	106.133	.059	.121
Presence of hexagon X Lag	(3,57)	8.549	58.907	.000	.310
Meaning X Lag	(3, 57)	.455	49.435	.715	.023

Figure 17: T2 accuracy as a function of lag, hexagon present and meaning



of hexagon, meaning, and lag also indicated that the presence of the red hexagon led to attentional capture at short temporal lags but peripheral elements that did not form a face impaired T2 identification to a greater extent than the peripheral elements that formed a face. Therefore the impairment in T2 identification appears to be due to the presence of the red hexagon rather than whether the peripheral elements formed a face. Further, verbal reports collected after the completion of the experiment showed that 90% subjects were aware of the red hexagon but only 30% reported seeing the face. This indicates that the red hexagon captured central attention without increasing the focus of attention as was proposed by Folk et al. (2008).

Alternatively, it is possible that because the target location does not vary, subjects benefit from keeping their focus of attention over the target location to ensure that they can identify the target, rather than broadening attention involuntarily in response to the appearance of the hexagon. The results of Experiment 6 are consistent with this interpretation. The results of Experiment 4a show that subjects can report the identity of the perceptual groups from the RSVP sequence when they are not required to report the identity of the centrally-located target letter. This suggests that if attention could be momentarily disengaged from the RSVP sequence then the peripheral elements would be brought under the focus of attention and processed as a whole. In Experiment 7, a brief discontinuity in the sequence was introduced by omitting the letter accompanying the peripheral distractors, as well as the letter in the position before and after the frame in which the peripheral elements were presented. Clearly, this kind of discontinuity will disrupt processing of T2. However, of interest is whether the presumed increase in the visibility of the perceptual group will now allow meaningful stimuli to capture attention more strongly than meaningless stimuli.

11 Experiment 7 Can the Gestalt Faces Capture Central Attention When the RSVP Sequence is Interrupted?

In this experiment the RSVP sequence is interrupted to disengage the focus of attention from the highly focused mode induced by attending to the RSVP sequence. Nieuwenstein et al. (2005) showed that the presence of a target in an RSVP sequence leads to the allocation of attention to the target location in the same way as is induced in the cueing paradigms. However, the presence of a distractor letter or even a blank screen leads to disengagement of attention from the same location to prevent task-irrelevant information from being processed unnecessarily. Impairments in T2 identification observed in this RSVP paradigm can therefore be used as an index to monitor the time taken for the attentional system to reengage rapidly (Nieuwenstein, Potter, & Theeuwes, 2009). This paradigm will be used in Experiment 7 to test whether the identity of the perceptual group (face) can be processed after attention is disengaged from the highly-focused mode induced by the RSVP sequence, perhaps allowing central attention to be captured more strongly by faces than by non-faces; this in turn could lead to greater impairment in T2 identification. One hypothesis is tested in this experiment

11.1 Hypothesis 1

If interruption in the RSVP stream causes the focus of attention to disengage from the target location then the identity of the perceptual group will be processed leading to greater impairment in T2 identification when the peripheral elements form a face than when they do not, particularly at short lags.

11.2 Methods

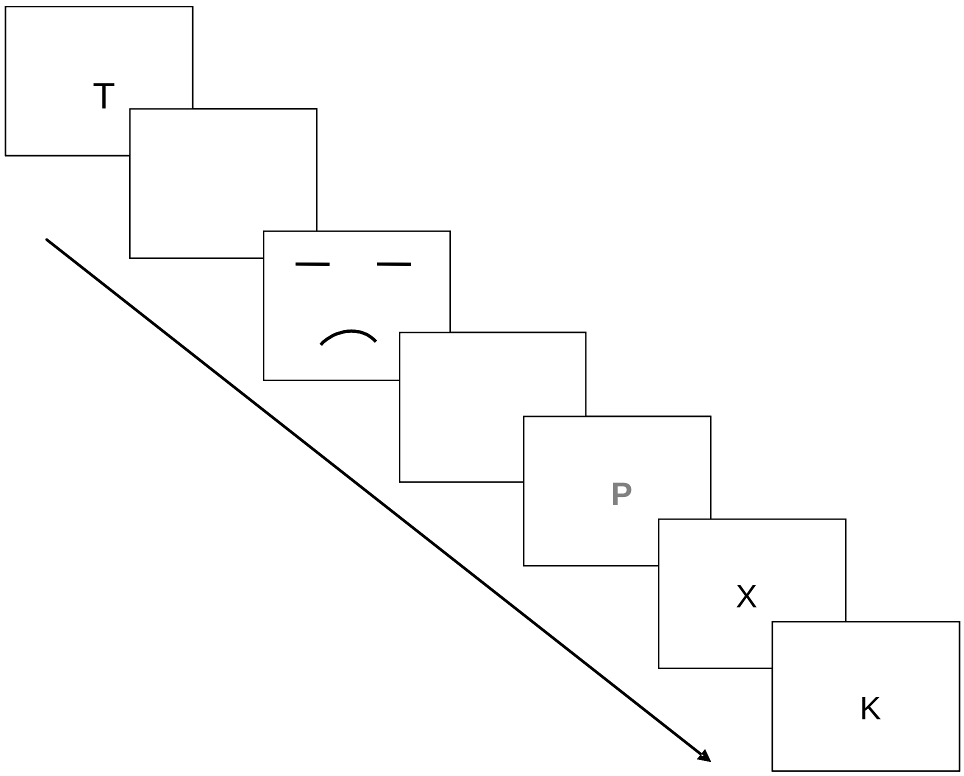
11.2.1 Subjects. Sixteen students participated in this experiment

11.2.2 Procedure and design. Experiment 7 was exactly same as mentioned in the General Methods, with three changes. First, distractor elements were always presented in black; that is, the manipulation of relevance was removed. Second, the distractor letter in the frame before, in, and after the frame in which the peripheral elements were presented was removed. The onset of the blank was varied randomly between the 6th and 10th position in the sequence. Third, the frame after the frame in which the peripheral elements were presented (i.e., the lag 1 position) was a blank frame; therefore, the target letter could be presented in lag positions 2, 5, and 8 only. Please refer to Figure 18 for the events on a trial in Experiment 7.

11.3 Results

The mean T2 accuracy scores were arcsine transformed and was the dependent variable and meaning (face/ non-face) and lag (2, 5, 8,) were the independent variable. A repeated measures ANOVA showed that the main effect of meaning was not significant $F < 1$; T2 accuracy was not influenced by whether the peripheral elements formed a face (M = .79) or not (M = .80). The main effect of lag, $F(2, 30)$ =15.8, MSE = 111.4, $p <$ .001, η_p^2 = .51, was significant, showing that the interruption in the RSVP stream captured attention such that T2 identification was impaired to a greater extent at short temporal lags than at longer lags. The interaction between meaning and lag was not significant $F < 1$. Please refer to Figure 19 for the mean accuracy in each condition. Verbal reports collected from subjects showed that 56% of subjects reported seeing the face on the experimental trials. Thus, it was possible to contrast performance for those

Figure 18 shows the events on a trial on a meaningful discontinuous trial with three blanks in Experiment 7.

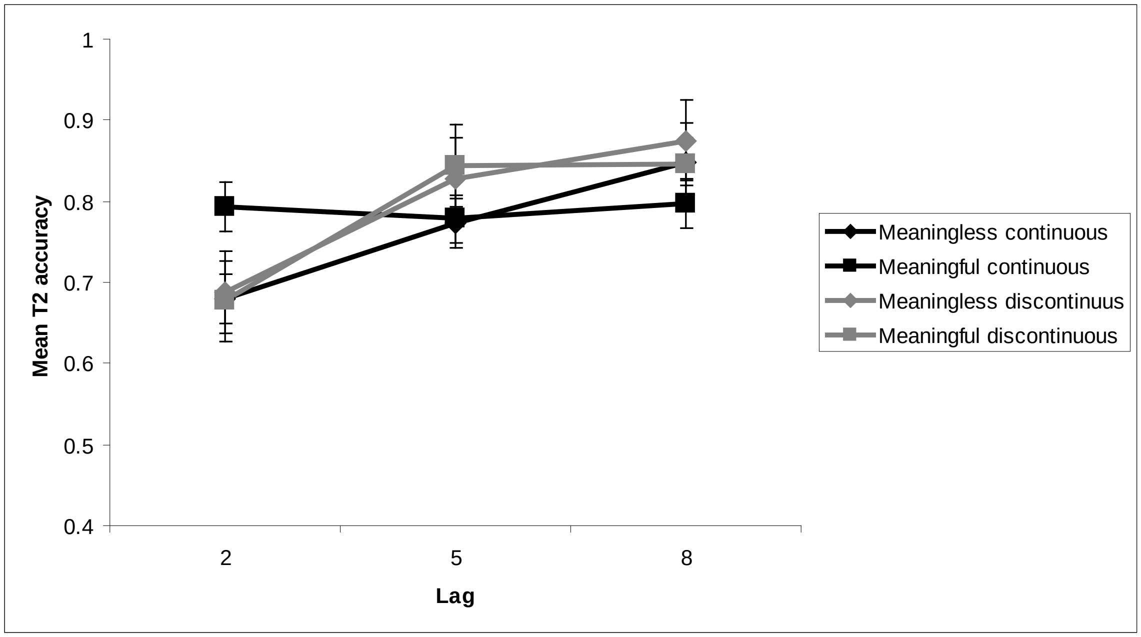


who saw the faces with those who did not. Another mixed model ANOVA was carried out to test whether T2 accuracy varied as a function of whether or not subjects were aware of the presence of the faces on the experimental trials. The main effect of awareness of the face was only marginally significant, $F(1, 14) = 3.7$, $MSE = 598.87$, $p < .08$, $\eta_p^2 = .21$, indicating that the subjects who were aware of the faces tended to identify the target more accurately ($M = .84$) than the subjects who reported not seeing the face ($M = .73$).

11.4 Discussion

The results of Experiment 7 yet again provide support for the observation made in the five preceding experiments that T2 identification was not disrupted by peripheral elements that formed a face. The discontinuous trials were introduced in this experiment to disengage attention from the target location so that the peripheral elements would be processed and the identity of the peripheral elements would then perhaps capture central attention to a greater extent than random arrangements of the lines. Consistent with the finding of Experiment 2 in the study carried out by Nieuwenstien et al. (2009), a significant effect of lag was observed suggesting that an AB was induced by this disruption in the absence of T1. The characteristics of the peripheral elements (two black straight lines and a black curve) did not obviously match any aspect of the target letter, so it would perhaps not be surprising that extensive processing of these elements did not occur. If the identity of the perceptual group was not processed, meaning would not be expected to exacerbate the AB. Verbal reports collected from subjects after the completion of the experiment showed that 56% of the subjects were able to report the presence of the face. This is higher than what was observed in any other experiment in

Figure 19: T2 accuracy as a function lag, meaning and continuity (continuous trials, Experiment 2 and discontinuous trials Experiment 7).



the present study, suggesting that when attention was disengaged from the target location it might be available for the processing of other stimuli. Although some subjects might have processed the identity of the perceptual group (face) this did not appear to interfere with T2 identification. The difference between the accuracy of T2 identification in subjects who reported seeing the face and those who did not see the face was marginally significant but the means were opposite the direction than was expected if meaningful groups capture more attention than meaningless groups; that is, subjects who reported seeing the face were also able to report the identity of T2 with greater accuracy than those who did not see the face. It appears that the RSVP paradigm creates a situation in which the attentional system is adjusted in a way that excludes processing of task-irrelevant features, as has been proposed by the various AB theories (Di Lollo, et al., 2005; Chun & Potter, 1995; Raymond et al., 1992). Consequently, a distractor letter, blank, or peripheral elements not matching a target will not be processed.

In summary, when the RSVP stream was interrupted by omitting the distractor letters from three frames, T2 identification was impaired to a greater extent at short temporal lags than at longer lags. This observation is consistent with the findings of Nieuwenstein et al. (2009) in which introduction of a blank after T1 was proposed to disengage attention from the target location. Additionally, more subjects were aware of the presence of the face on the experimental trials than in the preceding experiments, but meaning (i.e., a Gestalt face) did not capture central attention in a way that was detrimental for T2 identification. The Gestalt face that captured spatial attention in Experiment 1 when the target was searched in space failed to capture attention when the target was searched in time.

12 Summary of Results

The present study was carried out to investigate whether meaning of social and biological significant but irrelevant to the current task can capture central attention in a way that is detrimental to target identification when the distribution of spatial attention is discouraged. I was also interested in examining whether meaning proposed to be processed automatically or with minimal attentional resources can be extracted from minimal information and whether such meaning would then modulate capture of central attention impairing target identification. Seven experiments were carried out to test this research question. Observations made in each of the experiments are summarised in Table 7.

13 General Discussion

The present study was carried out to examine whether meaning that is associated with a stimulus outside of the experimental context can capture central attention in a way that is detrimental to target identification. The results from six experiments suggest that it is possible to prevent distractions from socially and evolutionarily-important stimuli like Gestalt faces. It also appears that the identity of some perceptual groups like faces can be processed only when the group as a whole is brought under the focus of spatial attention or when it fits the top-down attentional setting adopted to accomplish the current task (Sy & Giesbrecht, 2009). In the present study the RSVP paradigm was chosen in order to discourage the spread of spatial attention (as shown by Jefferies & Di Lollo, 2009), such that the perceptual group was probably not brought under the focus of spatial attention. The identity of the perceptual group was not processed and therefore the emotional faces did not capture central attention in a way that was more detrimental to subsequent target

Table 7: Summary of the results

Target searched in space in a visual search task.			
Experiment	Research question	Manipulation	Did face impair target identification?
1	Can Gestalt faces capture spatial attention?	Presence/absence of target Presence/absence of face	Effect on letter identification task No effect on perceptual group task
Target searched in time in an RSVP sequence, report red target T2 only.			
Experiment	Research Question	Manipulation	Did face impair T2 identification?
2	Can Gestalt faces capture central attention?	Relevance (black/red) Lag, Face/non-face	No effect on T2 identification
3	Do Gestalt faces impair the identity of the prime?	Relevance (black/red) Lag, Face/non-face	Effect of prime reduced No effect on T2 identification
4	Do Gestalt faces impair the report of a target presented in the same frame?	Report T1 and T2 Relevance (black/red) Lag, Face/non-face	T1 accuracy is impaired No effect on T2 identification
4a	Did task instruction bias subjects?	Free report and identification of gestalt group from RSVP sequence	Gestalt face identified No effect of knowledge of face on T2 identification
5	Can varying size increase the focus of attention, leading to interference from the Gestalt face?	Stimulus size varied Relevance (black/red) Lag, face/non-face	Large distractor letter impaired T2 identification No effect of face on T2 identification
6	Can a hexagon increase the focus of attention?	Hexagon (present/absent) Lag, Face/non-face	Hexagon impaired T2 identification No effect of face
7	Can interruption in the RSVP sequence lead to the processing of the face?	Discontinuous/ continuous Lag, Face/non-face	No effect on T2 identification

identification than captured by non-faces. Finally, observations made in this study show that the mechanism involved while searching for targets in time is different from the mechanism involved when searching for targets in space.

In the present study the experimental paradigm employed by Folk et al. (2008) was modified to investigate the way in which the presence of a Gestalt face in the stream captured central attention as shown by subsequent target identification. The results from six experiments showed that central attention was captured by the presence of peripheral elements in the RSVP sequence and these elements served as T1. Consistent with the findings from other studies using this paradigm, T2 identification was impaired when T2 was presented in close temporal proximity to T1. The attentional capture by task-relevant peripheral elements was more pronounced at shorter lags than at longer lags. Consistent with the findings of Folk et al. (2002, 2008), T2 identification was impaired more when the peripheral elements matched the target colour than when they did not. This suggests that the extent of attentional capture by the peripheral elements was contingent on the degree to which these elements matched the top-down setting modulating the allocation of central attention for the current task, and is consistent with the contingent involuntary orienting hypothesis proposed by Folk, Remington, and Johnston (1992). Irrespective of whether or not the peripheral elements matched the target colour, meaning (face) did not influence T2 identification in Experiments 2 through 5; the manipulation of task relevance was excluded from Experiment 6 and 7. Further, overall observations made in six experiments repeatedly showed that subjects were successful in filtering out the peripheral elements and the ability to report the identity of T2 was not influenced by whether or not these elements formed a face. However, the results of Experiment 4a showed that the identity of the perceptual group could be reported accurately from the RSVP sequence when that was the task goal. In Experiments 5-7 attempts were made to increase the focus of attention to bring the peripheral elements under the focus of central attention. In Experiment 5 the size of the letters in the stimulus display was varied such that a wider focus of attention would be adopted. The results of this experiment showed that T2 identification was impaired to a greater extent when a large distractor letter was presented with the peripheral elements, showing that a larger distractor letter allowed the peripheral elements to be processed to a greater extent. However, meaning did not further exacerbate this impairment. Additionally, more subjects were aware of the presence of the face in the RSVP sequence when the sequence was interrupted in Experiment 7 however even in this case faces did not interfere with T2 identification. This indicates that in the present study the identity of the perceptual group was not processed and therefore it was possible to prevent distraction from the Gestalt face. This effect could not be ascribed to the task instructions that directed subjects to ignore the two straight lines and the curve, or to the stimulus itself. The results of Experiment 4a clearly indicated that the identity of the perceptual groups formed from the various arrangements of the two straight lines and the curve could be reported freely and also in the RSVP sequence when task requirements were altered. Additionally, in the same experiment T2 identification was not influenced by whether or not the peripheral elements formed a face, even when subjects were aware that a face might be shown on some experimental trials.

The Gestalt faces that failed to capture central attention in Experiments 2-7 impaired target detection when the target was embedded in the perceptual group forming a face in a visual search task in Experiment 1. Consistent with the findings of other visual search studies (Eastwood et al., 2003) this effect was observed only when the target formed a part of the meaningful perceptual group (face) and not when the face was another object in the stimulus display.

The results of the present study are interesting and informative because they speak to three main aspects of attentional capture, which are discussed in detail in the next section.

13.1 Faces and Attentional Capture

Visual search experiments have shown that certain objects like affective faces modulate the allocation of attention under various demanding situations. Emotional faces have been observed to be processed under high perceptual load (Lavie et al., 2003), by individuals with brain damage (Vuilleumier & Schwartz, 2001), and even when they are task-irrelevant (Eastwood, et al., 2003) or presented outside the focus of attention (Forster & Lavie, 2008; Vuilleumier et al., 2001). Processing of affective stimuli is observed to be prioritized over neutral ones (Vuilleumier et al., 2001; Vuilleumier & Schwatz, 2001). Further, because emotional faces are proposed to be processed automatically in a bottom-up manner they capture attention preattentively and then direct allocation of attention in the visual field. Evidence for this claim comes from fMRI studies (Vuilleumier et al., 2001, Whalen et al., 1998), attentional blink studies (Maratos et al., 2008; Maratos, 2012; Srivastava & Srinivasan, 2010), and masking studies (Mogg & Bradley, 1999; Morris et al., 1998). A review of the literature examining attentional capture by affective faces strongly suggests that it is extremely difficult to prevent interference from affective faces for both neurotypical subjects and for subjects with brain damage. However, recently this view has been challenged and there is evidence indicating that attention is required to process emotional faces (Barrata & Bundensen, 2012; Eimer, Holmes & McGlone; 2003; Pessoa, Japee, Sturman, & Ungerleider, 2006; Pessoa, et al., 2002). Further, Pessoa et al. (2002) have claimed that a possible reason affective faces were observed to be processed without attention in some studies was because attentional resources were left over after the completion of the primary task and were therefore available for the processing of the affective faces. Additionally, other studies have shown that interference from Gestalt faces can be eliminated by increasing the bottom-up salience of individual target elements within the perceptual group (Eastwood et al., 2008) and also when the Gestalt faces do not match the attentional control setting adopted for the current task (Barratt & Bundensen, 2012). Consistent with these claims, the results of the present six experiments repeatedly show that it is possible to create an attentionally-demanding situation in which distractions from peripherally-located Gestalt faces are not observed. Two conditions seemed crucial for creating this attentionally-demanding situation. First, it is important to discourage allocation of attention to other locations where the target will not be presented. In the present study this was achieved by controlling the location of the target and distractors by employing the RSVP paradigm (Jefferies & Di Lollo, 2007). Because the peripheral elements were presented 1.4° from the edge of the centrally-located target letter, they were further away from the target location. Additionally, the items in the stimulus set are presented for a brief durations therefore it is advantageous to concentrate attentional resources narrowly over the target location to ensure accurate target identification. Second, it is important to maintain the attentional filter in a way that allows only task-relevant information to be selected for processing. In the present study this was achieved by presenting peripheral elements that did not match any aspect of the relevant stimulus set that subjects monitored to identify the target except when they matched the target colour on task-relevant trials. The abrupt onset of the task-irrelevant peripheral elements capture attention to some extent an effect supported by the main effect of lag on task-irrelevant in Experiments 2, and 3. Attention capture is consistently observed in all six experiment when the peripheral elements share the target colour. Nevertheless, a detailed comparison of the experimental design of the present study with others in which faces and other meaningful stimuli were claimed to capture attention will help to identify study differences that might have contributed to observed differences in the results. Further, such a discussion will also clarify the way in which it was possible to create an attentionally-exhausting situation in the present study.

13.2 Socially Important Stimuli and AB

Several attentional blink experiments have observed that when T2 was an emotional target word (Anderson, 2005; Anderson & Phelps, 2001), personal names (Shapiro et al., 1997), or an iconic happy face (Mack et al., 2002; Srivastava & Srinivasan, 2010), subjects were able to report T2 with greater accuracy than when T2 was a neutral word or picture. This suggests that, like spatial attention, central attention is modulated by affective words and pictures. Additionally, sexually provocative words (Arnell et al., 2007) or threatening or arousing pictures (Most et al, 2005; Most et al., 2007) induce an AB impairing the ability to report a colour target word or a neutral picture later in the stream although subjects were not required to report the sexually provocative word or the threatening picture or the arousing picture, suggesting that target accuracy is influenced by sexually provocative words, threatening pictures and arousing pictures. In contrast, the results of the present study show little evidence that peripheral elements forming a face captured central attention to a greater extent than random arrangements of lines. Consistent with the findings of Awh et al. (2004) it is possible that in the present study the target could be identified on the basis of a feature defined experimentally therefore faces requiring global processing did not impair T2 identification. Sy and Giesbrecht, (2009) observed that T2 identification was impaired by the emotional valence of a face when it was task-relevant or when subjects were required to report the valence of the two target faces. In the present study subjects were not required to report on any aspect of the face therefore face distractors did not interfere with T2 identification and impaired T2 identification was only observed when the peripheral elements matched the target colour, and hence were task-relevant. Further, other studies show that socially-defined meaning (Barnard, et al., 2004; Huang et al., 2008) only interferes with T2 identification when the target can be distinguished from the distractor in the stream on the basis of meaning. Additionally, several differences can be identified between the studies showing attentional capture by emotional words or pictures and the present study. The differences are discussed under three main categories

13.2.1 Focus of attention. The research questions addressed by the studies showing central attention capture by emotional words or images were different from those addressed in the present study. Consequently, different experimental designs were adopted in these studies. In a number of studies the researchers investigated the effect of an arousing word (Anderson & Phelps, 2001), sexually provocative word (Arnell et al., 2007), happy face (Mack et al., 2002), own name (Shapiro et al., 1997), on central attention. The stimulus was presented at the target location. In contrast, the present study was carried out to examine whether meaning associated with a task-irrelevant stimulus outside the experimental context and located at the periphery can capture central attention. Therefore, the peripheral elements forming a face were presented outside the target location in the present study and central attention capture was not observed in Experiments 2-7. It is important to note that in these experiments the spread of spatial attention (except Experiments 6 and 7 in which attempts were made to increase the focus of attention) was strongly discouraged by controlling the location at which the stimuli were presented and additional demands were imposed on the attentional system by restricting the duration of each item and manipulating the target onset using the RSVP paradigm. However, when the target was searched in space in Experiment 1 the same Gestalt affective faces were observed to interfere with the primary task as is also seen in the study by Eastwood et al. (2003). In Experiment 1, the target could be located anywhere in the stimulus display and the duration of the stimulus display was not restricted. Therefore, attention to the affective Gestalt face impaired target identification. This indicates that the non-significant effect of faces on central attention capture in the present study could have been because in the present study the Gestalt face was located away from the target location and therefore away from the direct focus of attention.

13.2.2 Matching the top-down attentional setting for the current task. Second, all the emotional words or pictures were part of the relevant stimulus set in the studies showing central attention capture. In these studies (Anderson & Phelp, 2001; Anderson, 2005; Shapiro et al., 1992) subjects were required to report the identity of a target word. Therefore, the meanings of stimulus words were required to be processed to report the identity of the target words. Similarly, in the study by Mack et al. (2002) subjects were required to report the presence of a shape from a sequence of other images and the iconic face was an item in the stimulus set. In the study by Most et al. (2005) subjects were required to judge the orientation of the picture and therefore they had to study the picture to some extent to identify the picture that was upside down. In contrast, subjects in the present study were required to report the identity of a red letter. As such, when the peripheral elements did not share the target's colour they did not match any aspects of the relevant stimulus set and were not part of the relevant stimulus set. Further, consistent with the findings of Folk et al. (2002, 2008), the peripheral elements captured central attention to a greater extent when they matched the target colour than when they did not. This indicates that the top-down settings can be very specific, and impairment in T2 identification is only induced when another event in the sequence matches the target features or when it matches the specific top-down attentional settings adopted for the current task (Maki & Mabane, 2006). Consistent with this claim interference from emotional words (Huang, Baddeley & Young, 2008) or faces (Barratt & Bundensen, 2012) can be eliminated when the target can be identified on the basis of other features.

13.2.3 Difference in the stimulus characteristics. Several differences are also observed in the nature of the affective stimulus used in the present study and those in which meaning was observed to modulate allocation of attention. In the study by Vuilleumier et al., (2001) in which unattended faces were observed to capture attention, photographs of actual fearful faces were used as stimuli. In the present study Gestalt faces could be perceived only when the peripheral elements were perceptually grouped as a happy or a sad face. Consistent with results of the study by Eastwood et al. (2003), in the present study interference from Gestalt affective faces was observed on the primary task when a target was searched in space in Experiment 1 but not when the target was searched in time as in Experiments 2 through 7. Further, studies proposing automatic processing of faces also used faces displaying negative affect, like fear (Anderson, et al., 2003, Anderson & Phelps, 2001). In contrast only happy or sad Gestalt faces were used in the present study. Schübo et al. (2006) observed that threatening faces were detected faster when the schematic faces were defined by discrete boundaries, but the effect of emotion was not present when the discrete boundary was removed. This indicates that emotions might not be perceived when the stimulus pattern is not perceived as a face. Further, the absence of the boundary defining the faces in the present study might have interfered with the perception of the Gestalt face when the faces.

In summary, comparison of the experimental designs of studies reporting attention capture by meaningful stimuli with the experimental design of the present study clearly shows that meaning captures central attention when it matches the top-down settings guiding the allocation of central attention. Additionally, interference from affective Gestalt faces will impair a primary task when the identity of the perceptual group as a whole is extracted. Certain emotions like fear and disgust might be processed automatically thereby modulating allocation of attention.

Alternatively, the difference between the results of Experiments 2 through 7 and Experiment 1 might be due to the differences in the mechanism employed to resolve spatial uncertainty and temporal uncertainty of the target.

13.4 Role of Attention in Resolving Spatial or Temporal Uncertainty

With spatial uncertainty it might be necessary to spread spatial attention throughout the entire visual field to locate the target. However, due to limited attentional resources it might not be possible to sample multiple probable target locations in the visual field concurrently (Posner et al., 1980). Further, distractors present within the same visual field compete for limited attentional resources. Some of this competition can be reduced by perceptually grouping the objects on the basis of laws of perceptual grouping like similarity and proximity (Kumada & Humphreys, 2001; Linnell & Humphreys, 2007). Therefore, instead of allocating attention to individual items or individual locations, attentional resources are allocated to the perceptual group as a whole and the area encompassed by the perceptual group (Dodd & Pratt, 2005). Processing of a target located in the space encompassed by the perceptual group is then prioritised over processing of a target located in the space not encompassed by the perceptual group (Chen, 1998; Egly et al., 1994). However, this process of organising the visual field into perceptual groups can also prove to be detrimental to target detection especially when the target's identity is amalgamated within the identity of the perceptual group as a whole (Eastwood et al., 2008). Logically, organising the various objects in the visual field into units can help deal with limited attentional resources under conditions of spatial uncertainty of the target. However, whether such organization is beneficial or not depends on the nature of the task and the way in which such organization influences target detection. The results of Experiment 1 of the present study show that the various elements were organised into *units* (Scholl, 2001) when the target location was unknown. The straight lines, the curve, and the letters were grouped together to form perceptual groups (face/ non-face) on the basis of the proximity of these elements to each other. Attention was then allocated to the perceptual groups as a whole. Consequently, the time taken to identify a target when presented within an affective Gestalt face was longer than when presented inside a non-face. However, the same affective Gestalt face did not interfere with target identification when the target was a perceptual group itself. Further, the Gestalt faces also did not interfere with target identification when the target location was controlled in Experiments 2 through 7. Consistent with claims made by Yeari and Goldsmith (2010), spatial attention was not spread over the entire space encompassed by the Gestalt face; that is, the object-based spread of attention was overridden in Experiment 2 through 7 because the target location was fixed and thus, there would be no advantage to spreading attention throughout the object. Neo and Chua (2006) also observed that attention can be focused narrowly by presenting a 100% valid cue or by always presenting the target in the same location, eliminating interference from distractors with abrupt onsets occurring frequently. Alternatively, as proposed by Kimchi (2009; also see Mack, Tang, Tuma, Kahn, & Rock, 1992) the results of the present study show that the identities of some perceptual groups can be perceived when the perceptual group as a whole is brought under the focus of attention. The fact that target identification was not influenced by the presence of the Gestalt faces in Experiments 2 through 7 indicates that the identity of the perceptual group was not processed. This conclusion is supported by the fact that only 33% of the subjects were aware of the faces in the experimental trials although they were exposed to these faces repeatedly.

13.4.1 Resolving temporal uncertainity. The challenges imposed on the attentional system are heavy with temporal uncertainty of target onset, as is observed in the attentional blink paradigm. In this paradigm a series of items are presented very briefly at a particular location and subjects are required to report the identity of two (or one in this study) pre-specified items in the series. The onset of the targets in the stream and the temporal difference between them is manipulated. In this case each of the items in the stimulus set has to be monitored because of the temporal uncertainity of the target and because the distractors share some features with the target. Once a target is detected, a more consolidated representation of the target has to be formed so that it can be reported later (Chun & Potter, 1995). There are limitations to the number of targets that can be processed and the speed with which processing of the first target can be completed. When two targets are presented in close temporal proximity (i.e., within 100 – 500 ms), identification of the second target is impaired, leading to the AB. AB can also be induced when irrelevant peripheral distractors match the target colour (Folk et al., 2002; Spalek, Yanko, Poiese, & Lagroix, 2012), when a uniquely coloured distractor letter is presented before T2 (Spalek, Falcon, & Di Lollo, 2006), when the colour of the distractor box in which the RSVP stream is presented matches the target colour (Folk et al., 2008), and when the target is presented at a location different from an irrelevant distractor that shares target characteristics (Ghorashi et al., 2003). This indicates that although the attentional system is monitoring the stimulus set for a pre-specified target characteristic, it is vigilant for other important stimuli in the visual field. Consistent with these studies, the results of the present study show that the sudden onset of the peripheral distractors also captured central attention in a way that was detrimental to T2 identification. In the present study subjects searched for a red letter (singleton) in a stream of black distractor letters. Therefore, it is possible that a singleton search mode was adopted. In singleton search mode the attentional filter is argued to be set rather leniently such that any singleton is selected and can capture central attention (see Folk et al., 2002; 2008). The peripheral elements were also singletons because no other items in the stream matched any aspect of the peripheral elements. The peripheral elements captured central attention but the identity of the perceptual group (i.e., the Gestalt faces) did not further exacerbate the AB. This indicates that the peripheral elements acted as singletons but the Gestalt faces did not. The AB induced by the peripheral elements was observed to be exacerbated when the peripheral elements shared the target colour and matched the top-down attentional setting responsible for monitoring the current behavioural goals. Although central attention was captured by the peripheral elements, the identity of the perceptual group was not processed. In all six experiments peripheral elements forming a face did not capture attention in a way that was detrimental to the processing of T2 although there was some evidence showing that processing of information (prime in Experiment 3, or T1 in Experiments 4 and 4a) presented in the same frame as the peripheral elements forming a face was impaired.

In summary, when there is temporal and spatial uncertainty spatial attention might be spread to all probable target locations (Conci & Muller, 2008; Jeferries & Di Lollo, 2009). The attentional filter is adjusted according to the top-down settings and allows the selection of task-relevant objects only. When a target is located at a particular location spatial attention might be withdrawn from the other probable locations and focused on the target. The target is selected by the attentional filter that is controlled by top-down settings and prevents selection of any other stimuli that are not relevant to the current task goals. Once the target is selected it gains access to a resource-demanding stage of processing such that a more consolidated representation of it can be formed. While this process is in progress other stimuli cannot be processed. The results of the present study indicate that several mechanisms might be activated when faced with an attentionally demanding task as in the present study. As has been communicated by Spalek et al. (2012), a global approach to understanding attentional capture is helpful in this case. Spalek et al. (2006) observed that the input-filtering models of central attention capture can account for attention capture by stimuli that match the top-down settings adopted for the current goal but cannot account for central attention capture by singletons. Spalek et al. therefore proposed a hybrid model that explains attention capture more generally and is an extension of the contingent capture idea of attention capture. Their hybrid model consists of an input filter that is modulated by the current task goals and allows selection of only the task relevant items for higher order processing. Spalek et al. also proposed the presence of a mechanism by which singletons can by-pass this input filter and can gain access to higher order processing. The results of the present study can also be explained by the hybrid model proposed by Spalek et al. (2006). In the present study, there was some evidence that peripheral elements acted as singletons in the stream and that they successfully bypassed the filtering system that was implemented by the current task goals leading to central attention capture in a way that was detrimental to T2 identification. This interpretation is supported by decreased T2 identification accuracy at short temporal lags in Experiment 2 and 3 when only task-irrelevant trials were analysed. When the peripheral elements were task relevant they gained access to the higher order processing by being selected, thereby impairing T2 identification. However, it is important to note that in the present study although the peripheral elements gained access to the higher order processing, the identity of the perceptual group that was formed by the peripheral elements was not processed, irrespective of task relevance. The results of the present study also indicated that the identity of the perceptual group could be perceived when it was brought under the focus of attention (by eliminating the letter identification task) or was part of the relevant set. This indicates the presence of another mechanism that probably monitors allocation of attention spatially and evaluates the features present in the selected items for task relevance. Therefore I propose a flexible multi-modal attentional system to account for the findings of the present study.

14 Multi-process Attentional System

The multi-process attentional system I propose here is an extension of the hybrid model proposed by Spalek et al. (2006). I propose the presence of two sub-systems. One of the sub-systems monitors the spread of spatial attention and is greatly influenced by the knowledge of target location. Another sub-system, referred to as a hybrid attentional filter (as proposed by Spalek et al., 2006), monitors the selection of relevant objects from the visual field. This model can account for all the observations made in the present study. First, in the present study the spatial location of the target and the stimulus set was controlled. Therefore, the spread of spatial attention was restricted by one of the attentional sub-systems and the affective face formed from the arrangements of the peripheral elements was not brought under the focus of spatial attention. Thus, fewer people were aware of the presence of the faces when carrying out the letter task. However, when asked to report the identity of the perceptual group as a whole, its identity could be reported from the RSVP sequence provided that subjects did not have to perform the letter identification task. Second, the hybrid attentional filter was adjusted to allow red letters to gain access to higher order processing. Consequently, an AB was induced and T2 identification was impaired by the peripheral elements when they matched the target colour. However, the task irrelevant yet unique peripheral elements gained access to the high order processing only by by-passing the filter. Consistent with the findings of Spalek et al. (2006), the AB induced by the task-irrelevant peripheral elements was weaker than that induced by the task-relevant peripheral elements. However, under either conditions the identity of the perceptual group formed (face) by the special arrangements of the peripheral elements was not processed because the perceptual group was not perceived as a whole.

15 Conclusion

Distractions from socially- and biologically-important stimuli like faces can be averted when attention is focused narrowly over a known target location. Further, the top-down attentional set adopted to accomplish a current task can also prevent processing of other important but task-irrelevant stimuli in an attention-demanding scenario.

References

Anderson, A. K. (2005) Affective influences on the attentional dynamic supporting awareness. *Journal of Experimental Psychology General, 134(2),* 258-81.

Anderson, A. K, Phelps, E. A. (2001) Lesions of the human amygdala impair enhanced perception of emotionally salient events. Nature 411(6835):305-9.

Anderson, A. K., Christoff, K., Panitz, D., Rosa, E. D., & Gabrieli, J. D. E. (2003). Neural Correlates of the automatic processing of threat facial signals. *The Journal of Neuroscience,23(13),* 5627-5633.

Arnell, K.M., Killman, K.V., Fijavz, D. (2007). Blinded by emotion: Target misses follow attention capture by arousing distractors in RSVP. *Emotion, 7(3),* 465-477.

Benso, F., Turatto, M., Mascetti, G. G., & Umiltà, C. (1998). The time course of attentional focusing. *European Journal of Cognitive Psychology, 10*, 373-388.

Barnard, P.J., Scott, S., Taylor, J., May, J., & Knightley, W. (2004). Paying attention to meaning. *Psychological Science* 15: 179-186

Cave, K., & Bichot, N. P. (1999). Visuospatial attention: Beyond a spotlight model. *Psychonomic Bulletin & Review, 6 (2)*, 204-223.

Chen, Z. (1998). Switching attention between and within objects. The role of subjective organization. *Canadian Journal of Experimental Psychology, 52(1),* 7-17.

Chen, Z., & Cave, K.R. (2008). Object-based attention with endogenous cuing and positional certainity. *Perception & Psychophysics*, 70(8), 1435-1443.

Chun, M. M., & Potter, M. C. (1995). A two-stage model for multiple target detection in rapid serial visual presentation. *Journal of Experimental Psychology: Human Perception & Performance*, 21, 109-127.

Conci, M. & Muller, H. J. (2009). The “beam of darkness”: Spreading of the attentional blink within and between objects. *Attention, Perception, & Psychophysics, 71 (8),* 1725-1738.

Dalton, P., & Lavie, N. (2006). Temporal attentional capture: Effects of irrelevant singletons on rapid serial visual search. *Psychonomic Bulletin & Review, 13(5),* 881-885.

de Jong, P. J., Koster, E.H.W., van Wees, R., & Martens, S.(2009). Emotional faces expression and the attentional blink: Attenuated blink for angry and happy faces irrespective of social anxiety. *Cognition And Emotions, 23(8),* 1640-1652

de Jong, P.J., Koster, E.H.W., van Wees, R., & Martens, S. (2010). Angry facial expression hamper subsequent target identification. *Emotions,10(5),* 727-732

Di Lollo, V., Kawahara, J., Ghorashi, S. M. S., & Enns, J. T. (2005). The attentional blink: Resource depletion or temporary loss of control. *Psychological Research*, **69**, 191-200.

Dodd, & Pratt, J (2005). Allocating visual attention to grouped objects. *European Journal of Cognitive Psychology, 17(4),* 481-497.

Duncan,J. (1984). Selective attention and the organization of visual information. *Journal of Experimental Psychology: General, 113(4),* 501-517.

Dux., P.E., & Mario, R. (2009). The attentional blink: A review of data and theory. *Attention, Perception, & Psychophysics,71(8),*1683-1700.

Eastwood, J. D., Frischen A., Reynolds, M., Gerritsen, C. Dubin, M., & Smilek, D. (2008). Do emotionally expressive faces automatically capture attention? Evidence from global local interference. *Visual Cognition, 16(2/3),* 248-261.

Eastwood, J. D., Smilek, D., & Merikle, P. M. (2003). Negative facial expression captures attention and disrupts performance. *Perception and Psychophysics, 65,* 352-358.

Eimer, M., Holmes, A., McGlone, F. P. (2003). The role of spatial attention in the processing of facial expression: An ERP study of rapid brain responses to six basix emotions. *Cognitive, Affective, & Behavioural Neuroscience, 3(2),* 97-110.

Egly, R., Driver, J., & Rafal, R. D. (1994). Shifting visual attention between objects and locations: Evidence from normal and parietal lesion subjects. *Journal of Experimental Psychology: General*, *113,* 501-517.

Eriksen, C. W., St James, J. D. (1986). Visual attention within and around the field of focal attention: A zoom lens model. *Perception & Psychophysics*, *40(4),* 225-240.

Forster, S., & Lavie, N. (2008). Failures to ignore entirely irrelevant distractors: The role of load. *Journal of Experimental Psychology: Applied, 14(1)*, 73–83.

Folk, C. L., Leber, A. B., & Egeth, H. E. (2002). Made you blink! Contingent attentional capture produces a spatial blink. *Perception & Psychophysics, 64(5),* 741-753.

Folk, C.L., Leber, A. B., & Egeth, H. E. (2008). Top-down control setting and attentional blink: Evidence for nonspatial contingent capture. *Visual Cognition, 16(5)*, 616-642.

Folk, C.L., Remington, R.W., & Johnston, J. C. (1992). Involuntary covert orienting is contingent on attentional control settings. *Journal of Experimental Psychology: Human Perception and Performance, 18(4),* 1030- 1044.

Fox, E., Lester, V., Russo, R., Bowles, R. J., Pichler, A., & Dutton, K. (2000). Facial expressions of emotion: Are angry faces detected more efficiently? *Cognition & Emotion*, 14, 61-92.

Ghorashi, S. M. S., Zuvic, S. M., Visser, T. A. W., & Di Lollo, V. (2003). Focal distraction: Spatial shifts of attentional focus are not required for contingent capture. *Journal of Experimental Psychology: Human Perception & Performance*, *29*, 78-91.

Girgus, J. J., Rock, I., & Egatz, R. (1977). The effect of knowledge of reversibility on the reversibility of ambiguous figures. *Perception & Psychophysics*, **22**, 550-556.

Hansen, C., & Hansen, R. (1988). Finding the face in the crowd: An anger superiority effect. *Journal of Personality and Social Psychology*, 54 (6), 917-924.

Howell, D.C. (2002) Simple analysis of Variance. *In Statistical Methods for Psychology*, (pp. 318-368),Duxbury Thomson Learning.

Huang, Y. M., Baddeley, A., & Young, A. W., (2008). Attentional capture by emotional stimuli is modulated by semantic processing. *Journal of Experimental Psychology: Human Perception and Performance*, 34 (2), 328–339.

Humphreys, G.W., & Riddoch, J. (2007). How to define an object: Evidence from the effects of action on perception and attention. *Mind & Language, 22(5),* 534–547.

Jefferies, L.N., & Di Lollo, V. (2009). Linear Changes in the Spatial Extent of the Focus of Attention Across Time. *Journal of Experimental Psychology: Human Perception and Performance, 35(4),* 1020–1031.

Johnston, J.C., McCann, R.S., & Remington. R.W. (1995). Chronometric evidence for two types of attention. *Psychological Science,* 6(6), 365-369.

Jolicoeur, P., Dell'Acqua, R., & Crebolder, J. M. (2001). The attentional blink ottleneck. In K. Shapiro (Ed.), *The limits of attention:Temporal constraints in human information processing* (pp. 82-99). Oxford: Oxford University Press.

Kanwisher, N. (1987). Repetition blindness: Type recognition without token individuation. *Cognition*, **27**, 117-143.

Kimchi, (2009). Perceptual organization and visual attention. *Progress in Brain Research* Vol 176.

Kumada, T., & Humphreys, G. W. (2001). Lexical recovery from extinction: Interaction between visual form and stored knowledge modulated visual selection. *Cognitive Neuropsychology, 18(5),* 465-478.

La Berge, D. (1983). Spatial extent of attention to letters and words. *Journal of Experimental Psychology: Human Perception and Performance, 9 (3),* 371-379.

Lavie, N., Ro, T., & Russell, C. (2003). The role of perceptual load in processing distractor faces. *Psychological Science, 14,* 510–515.

Landau, A.N., & Bentin, S. (2008). Attentional and perceptual factors affecting the attentional blink for faces and objects.*Journal of Experimental Psychology: Human Perception and Performance, 34(4),* 818-830

Linnell, K.J., & Humphreys, G.W. (2007). Top-down-driven grouping overrules the central attentional bias. *Journal of Experimental Psychology: Human Perception and Performance, 33(3),* 530–548.

Lipp, O. V., Price, S. M., & Tellegen, C. L. (2009). No effect of inversion on attentional and affective processing of facial expressions. *Emotion, 9(2),* 248–259.

Neo, G., & Chua, F. K. (2006). Capturing focused attention. Perception and Psychophysics, 68(8), 1286_1296.

Nieuwenstein, M.R., Chun, M. M., van der Lubbe, R. H. J., Ignace, T. C., & Hooge I. T. C. (2005) Attentional engagement in the attentional blink. *Journal of Experimental Psychology: Human Perception and Performance, 31(6),* 1463-1475.

Nieuwenstein, M. R., Potter, M. C., & Theeuwes, J. (2009). Unmasking the attentional blink. *Journal of Experimental Psychology: Human Perception & Performance, 35,* 159-169.

Mack, A., Tang, B., Tuma, R., Kahn, S., & Rock, I. (1992). Perceptual organization and attention. *Cognitive Psychol- ogy, 24,* 475–501.

Mack, A., Pappas, Z., Silverman, M., & Gay, R. (2002). What we see: Inattention and the capture of attention by meaning. *Consciousness and Cognition, 11,* 488-506.

Maki, W. S., & Mebane, M. W. (2006). Attentional capture triggers an attentional blink. *Psychonomic Bulletin & Review, 13*, 125-131.

Marcel, A.J. (1983). Conscious and unconscious perception: Experiments on visual masking and word recognition. *Cognitive Psychology, 15,* 197- 237.

Maratos, F.A. (2011). Temporal processing of emotional stimuli: The capture and release of attention by angry faces. *Emotions,* 11(3), 1242-1247.

Maratos, F. A., Mogg, K., Bradley, B. P. (2008). Identification of angy faces in the attentional blink. *Cognition and Emotion, 22(7)*, 1340-1352.

Marrara, M.T., & Moore, C.M. (2003). Object based selection in the two rectangle method is not an artefact of the three-sided directional cue. *Perception & Psychophysics*, 65, 1103-1109.

Mogg, K., & Bradley, B.P. (1999). Orienting of attention to threatening facial expressions presented under conditions of restricted awareness. *Cognition and Emotion 13,* 713–740.

Marino, A. & Scholl, B.J. (2005) The role of closure in defining the objects of object-based attention. *Perception & Psychophysics, 67(7),* 1140-1149.

Milders, M., Hietanen, J.K., Jukka M. Leppa¨nen, J.M., & Braun, M. (2011). Detection of emotional faces is modulated by the direction of gaze. *Emotions, 11(6),* 1456-1461

Miyazawa, S., & Iwasaki, S. (2010). Do happy faces capture attention? The happiness superiority effect in attentional blink. *Emotions,10(5),* 712-716

Morris, J.S., Ohman, A., & Dolan, R. J. (1998). *Conscious and unconscious emotional learning in the human amygdala. Nature,393,* 467-470.

Most, S. B., Chun, M. M., Widders, D. M., & Zald, D. H. (2005). Attentional rubbernecking: Attentional capture by threatening distractors induces blindness for targets. *Psychonomic Bulletin and Review, 12*, 654–661.

Most, S.B., Smith, S.D., Cooter, A.B., Levy, B.N., & Zald, D.H. (2007). The naked truth: Positive, arousing distractors impair rapid target perception. *Cognition And Emotion, 21(5)*, 964-981

Musch, K., Engel, A.K. & Schneider, T. R. (2012). On the blink: The importance of target-distractor similarity in eliciting an attentional Blink with faces. *Plos One, 7(7)* e41257

O¨ hman, A. (2002). Automaticity and the amygdala: Nonconscious responses to emotional faces. Current Directions in Psychological Science, 11, 62_66.

Pashler, H., & Johnston, J. C. (1989). Chronometric Evidence for central postponement in temporally overlapping tasks. *The Quarterly Journal of Experimental Psychology, 41A* , 19-45.

Pessoa, L., McKenna, M., Gutierrez, E., & Ungerleider, L.G. (2002). Neural processing of emotional faces requires attention. *PNAS, 99(17),* 11458-11463

Pessoa L, Japee S, Sturman D, Ungerleider LG. (2006). *Target visibility and visual awareness modulate amygdala responses to fearful faces. Cerebral Cortex,16,* 366-375.

Potter, M. C., & Levy, E. I. (1969). Recognition memory for a rapid sequence of pictures. *Journal of Experimental Psychology*, 81, 10-15.

Posner, M.I., Snyder, C. R. R., and Davidson, B. J. (1980). Attention and detection of signals. *Journal of Experimental Psychology: General 109 (2),* 160-174

Posner, M. I. (1980). Orienting of attention. *Quarterly Journal of Experimental Psychology, 32,* 3–25.

Peterson, M.A., & Gibson, B. S. (1994).Object recognition contributions to figure-ground organization: Operations on outlines and subjective contours. *Perception & Psychophysics*, *56(5),* 551–564.

Richard, A.M., Lee, H. l., & Vecera, S. P. (2008). Attention spreading in object-based attention. *Journal of Experimental Psychology: Human Perception and Performance, 34(4),* 842–853.

Ro, Lavie & Russell, (2001**)** Changing faces: A detection advantage in the flicker paradigm. *Psychological Science,12*, 94-99

Rauschenberger, R., & Yantis, S. (2001). Attentional capture by globally defined objects. *Perception and Psychophysics, 63*, 1250_1261

Raymond, J. E., Shapiro, K. L., & Arnell, K. M. (1992). Temporary suppression of visual processing in an RSVP task: An attentional blink? *Journal of Experimental Psychology: Human Perception &Performance, 18,* 849-860.

Schubo, A., Gendolla, G. H. E., Meinecke, C., & Abele, A. E. (2006). Detecting emotional faces and features in a visual search paradigm: Are faces special? *Emotion 6(2),* 246–256

Scholl, B.J. (2001).Objects and attention: The state of the art. *Cognition, 80(1–2),* 1–46.

Suzuki, S., & Cavanagh, P. (1995). Facial organization blocks access to low level features: An Object inferiority effect. *Journal of Human Perception and Performance, 21(4),* 901-913

Shapiro, K. L., Caldwell, J., & Sorensen, R. E. (1997). Personal names and the attentional blink: A visual ‘‘cocktail party’’ effect. Journal of Experimental Psychology: Human Perception and Performance, 23, 504_514.

Spalek, T.M., Falcon, L.J., & Di Lollo, V. (2006) Attentional blink and attentional capture: Endogenous versus exogenous control over paying attention to two important events in close succession. *Perception & Psychophysics, 68(4),* 674-684

Spalek, T.M., Yanko, M.R., Poiese, P., Lagroix, H.E.P. (2012). Unique sudden onsets capture even when observers are in feature-search mode. *Psychological Research, 78,* 8-19

Srivastava, P. & Srinivasan, N. (2010). Time course of visual attention with emotional faces. *Attention, Perception & Psychophysics, 72(2),* 369-377

Stein, T., Zwickel, J., Kitzmantel, M., Ritter, J & Schneider, W. X. (2010). Irrelevant words trigger an attentional blink. *Experimental Psychology, 57(4),* 301-307

Sy, J.L., & Giesbrecht, B. (2009). Target-target similarity and the attentional blink: Task-relevance matters. *Visual Cognition,17(3)*, 307-317

Van Selst, M., & Jolicoeur, P. (1994). A solution to the effect of sample size on outliers estimation. *The Quarterly Journal of Experimental Psychology, 47A,* 631-650

Vecera, S. P. (1994). Grouped Locations and Object-Based Attention: Comment on Egly, Driver, and Rafal (1994). *Journal of Experimental Psychology: General 1994, 123(3)*, 316-320

Vickery, T. J., & Jiang, Y.V. (2009). Associative grouping: Perceptual grouping of shapes by association. *Attention, Perception, & Psychophysics, 71 (4),* 896-909

Vuilleumier, P., and Schwartz, S. (2001) Emotional facial expressions capture Attention. *Neurology, 56,* 153–158

Vuilleumier, P., Armony, J. L., Driver, J., Dolan, R. (2001). Effects of attention and emotion on Face processing in the human brain: An event-related fMRI study. *Neuron, 30,* 829-841

Watson, D. G., Blagrove, E., Evans, C., & Moore, L. (2012). Negative triangles: Simple geometric shapes convey emotional valence. *Emotion,* 12(1), 18-22

Whalen, P.J., Rauch, S.L., Etcoff, N.L., McInerney, S.C., Lee, M.B., & Jenike, M.A. (1998). Masked presentations of emotional facial expression modulate amygdala activity without explicit knowledge. *Journal of Neuroscience,18,* 411–418.

Wolfe, J.M., Friedman-Hill, S.R., & Bilsky, A.B. (1994). Parallel processing of part-whole information in visual search tasks. *Perception & Psychophysics*, *55(5),* 537-550

Yeari, M., & Goldsmith, M. (2010). Is object-based attention mandatory? Strategic control over mode of attention. Journal of Experimental Psychology: Human Perception and Performance, *36(3),* 565–579

Appendix 1

Appendix 1: T2 accuracy as a function of meaning analysed separately on task-irrelevant and task relevant trials Experiment 2.

Analysis of T2 identification on task irrelevant trials. A significant main effect of lag was observed, $F(3, 75) = 12.64$, $MSE = 51.9$, $p < .001$, $\eta_p^2 = .34$, indicating that T2 identification was impaired at shorter lags to a greater extent than at longer lags even when the peripheral elements were task irrelevant. T2 identification was not influenced by whether or not the peripheral elements formed a face, $F(3, 75) = 2.5$, $MSE = 65.17$, $p > .13$, $\eta_p^2 = .09$. The interaction between meaning and lag was significant, $F(3, 75) = 4.98$, $MSE = 61.97$, $p > .003$, $\eta_p^2 = .17$, however, the interaction was in the opposite direction from what was predicted; that is, peripheral elements that did not form a face captured central attention at shorter temporal lags to a greater extent than peripheral elements forming a face.

Analysis of T2 accuracy on task relevant trials. The main effect of meaning was not significant, $F(1, 25) = .45$, $MSE = 59.8$, $p > .51$, $\eta_p^2 = .02$, indicating that even when the peripheral elements were task relevant T2 identification was not influenced by whether or not the peripheral elements formed a face. The main effect of lag was significant indicating that T2 identification was impaired at shorter lags to a greater extent than at longer temporal lags. The interaction between meaning and lag was significant, $F(3, 75) = 8.12$, $MSE = 53.26$, $p < .001$, $\eta_p^2 = .25$; although greater lag 1 sparing was observed for meaningless trials, the effect was in the opposite direction from that predicted, indicating that task relevant peripheral elements that did not form a face impaired T2 identification to a greater extent than task relevant peripheral elements forming a face (at lag 2 and 5 positions).

Appendix 2

Means of the accuracy with which T2 is identified as a function of lag, relevance and meaning and the baseline condition in Experiment 2

	Irrelevant		Relevant		Baseline
	Meaningless	Meaningful	Meaningless	Meaningful	
Lag 1	0.71	0.75	0.65	0.59	0.70
Lag 2	0.68	0.79	0.50	0.54	0.71
Lag 5	0.77	0.78	0.56	0.63	0.75
Lag 8	0.85	0.80	0.72	0.63	0.70